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Compressed Air Magazine

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CAISSON ENCOUNTERED IN CHICAGO SUBWAY TUNNEL

ON THE COVER

OUR cover picture shows a concrete caisson encountered in one of the Chicago subway tunnels at Wacker Drive and Lake Street. It forms part of the support of Wacker Drive. Its presence at this point was a surprise, as maps indicated its position to be 8 feet away and outside of the tunnel line. The steel ribs constituting the primary lining of the tunnel have been set on both sides of the column. In the background is the breast of the bore, showing the markings left by power-driven knives in slabbing off the characteristic stiff blue clay on which Chicago rests. The man at the left is handling one of the knives, although the cable extending from it to the hoist that pulls it was slack at the instant the picture was taken. At the right a workman is starting a hole in the concrete caisson with a Jackhamer rock drill. The structure was honeycombed prior to its demolition with paving breakers. This tunnel section was driven by Paschen Contractors, Inc.

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IN THIS ISSUE

CHICAGOANS have been climbing stairs to reach elevated railroads for so long that it will seem unnatural for them to descend below the ground level to gain access to their new rapid-transit system. Nevertheless, their transition into human moles will begin next year. Details of the construction of the initial 7.7-mile system are presented in our first article.

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IN THE year 1865, Louis Pasteur began a 3-year investigation of silkworm diseases that resulted in saving the silk industry of France and perhaps of the entire world. One of his students at the time was Count de Chardonnet who, as a consequence, became interested in silk culture and entered upon studies that later caused him to be acclaimed Father of Rayon. He and others demonstrated that artificial silk could be made; but its cost was greater than that of natural silk until the viscose process was developed by C.F. Cross and E.J. Bevan. More than 80 per cent of the world's rayon is now made from viscose. Our second article deals with its history and describes the principal manufacturing processes.

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WITHOUT the deep snows that blanket the Rocky Mountains each winter, there would be little to sustain life in the western cordilleran states. Snow, then, is a blessing, even though its removal from roads that cross the Continental Divide occasions some trouble. The commercial highways are kept open all winter; but in areas such as Rocky Mountain National Park no traffic passes over the high roads during two-thirds of the year, and the accumulated snows must be cleared away each spring to open them to travel. The evolution of methods and equipment for this purpose is traced in our third article.

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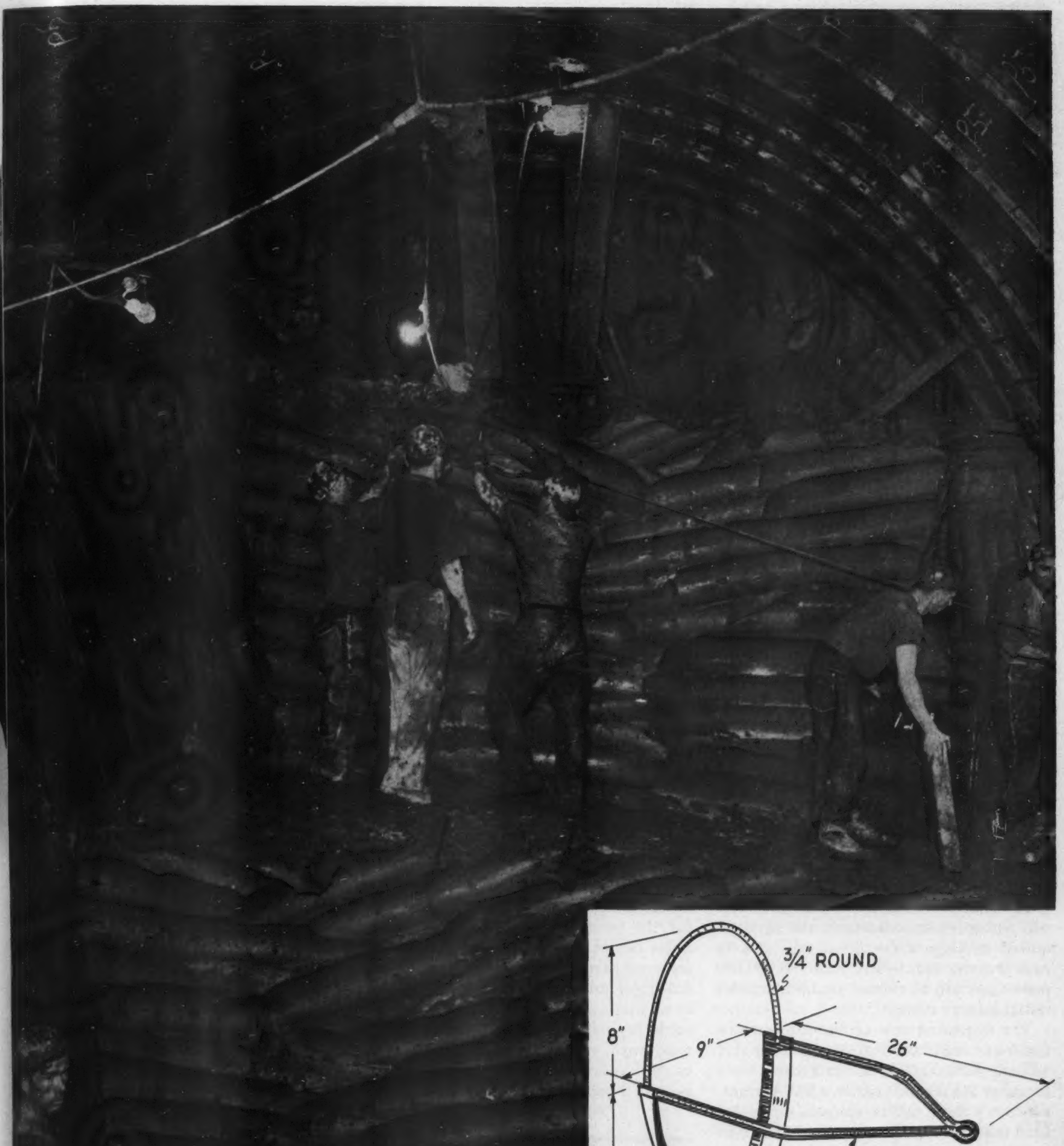
Chicago Builds a Subway

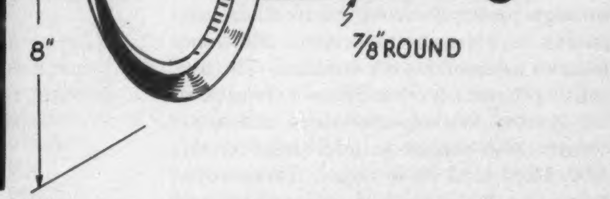
C. H. Vivian

SOME time next year, Chicagoans will take their first subway rides in their home city. Some of the passengers will be great-grandchildren of the men who first proposed an underground railway system for Chicago in the 1880's, for it has taken more than half a century to make the transition from debate to construction. During the interim, numerous schemes have been advanced and rejected. Thus, America's second largest city will, belatedly, become one of the group of municipalities that do a portion of their traveling beneath the streets. Boston built the first subway in this country in 1898, thirty-five years after subterranean transportation of persons was introduced in London. New York opened its first subway in 1904, and now, with 133 route-miles, leads all other world cities in mileage. Philadelphia's first subway was constructed in 1908.

Chicago's first subway is visioned as the nucleus of a future comprehensive network, and from that viewpoint the lines now being built are considered primarily as the hub of the ultimate system, together with short stretches of the branches that will eventually radiate from this central area to various parts of the city. They will, nevertheless, give immediate relief to existing, congested transit facilities in the downtown "Loop" section, where trains on the 43-year-old elevated railroad system are so numerous during rush hours as to slow them down to an almost intolerable low speed. The coming of a subway is hailed by Chicagoans as an epochal event in the history of the city, as it has been recognized for a long time that its progress was being greatly hampered by the lack of adequate transit facilities. The present street and elevated transportation agencies have been so overloaded for several years that there has been a distinct tendency to establish business and shopping sections outside the central commercial district.

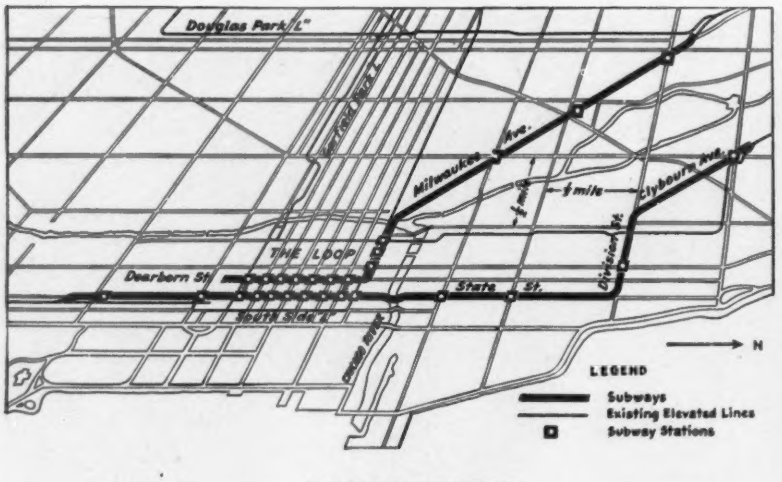
The initial system will consist of 7.7 route-miles of double-tube subway. It is divided into two lines, known as the State Street and Dearborn Street subways, these being the names of the two streets where most of the passengers will board or leave trains in the downtown business area. Except for a short extension of the State Street subway to the south, both lines will run north and northwest from the Loop district. The Dearborn Street section will go out Lake Street and Milwaukee Avenue, emerging near Paulina Street to connect with the Logan Square-Humboldt branch of the elevated railroad. It will be 3.3 miles long. The State Street section will run northward to Division Street, thence westward to Clybourn Avenue, following the latter thoroughfare to a point near North Avenue where it will come above ground to





EXCAVATING PROCEDURE

In the horseshoe-shaped tunnels, the plastic clay is cut off in strips which are hand loaded into cars for disposal. The excavation is advanced on three levels or benches, as seen above. The men at the top heading are slabbing off the clay with hand-drawn knives while one of the workman at the middle face is operating a power-driven knife, details of which are shown in the drawing. It is drawn across the clay face by a wire rope that passes over a sheave and then to an air hoist located from 30 to 50 feet back of the heading. Up to six knives are used at a heading, and more than 100 Ingersoll-Rand hoists are employed in the work. Some of these are illustrated on the preceding page. The one at the bottom is operating a knife in a shield being used to advance a section of the circular tunnel. Another application of these handy and powerful machines is shown at the upper left. This unit is employed to haul muck cars to and from a heading. At the left in the picture is a 4-cubic-yard car of the Chicago Freight Tunnel System loaded with slabs of clay.



MAP OF ROUTES

It will be readily seen how this initial 7.7-mile system can be made the nucleus of a comprehensive network connecting all outlying sections of the city with the central Loop district. The tunnels north of the river are being constructed of horseshoe section: those south of the river, where softer clay occurs, are being built by the shield method and are circular.

THE HOLE IN THE DRESSING-ROOM FLOOR

For the most part the subway runs beneath the streets, and abutting structures do not have to be supported. There are exceptions, however, and one of these is at Lake and Dearborn streets where a turn carries the line under a large building that houses the Harris and Selwyn theaters. Prior to tunneling, this structure was shored up. The picture at the right shows a workman with an air-driven clay spade digging a trench in the floor of the dressing room for a girder to be used in underpinning.

merge with the North Side and Ravenswood branch of the elevated system. It will be 4.4 miles long. Although they are relatively short, it is estimated that these initial links will make possible savings in time of from 3½ to 12½ minutes for passengers traveling between State and Madison streets and various outlying areas to the south, north, and northwest. It is also expected that they will reduce the maximum hourly movement of elevated trains in the Loop from 68 to 38 trains and that this will cut seven minutes from the time required to make a circuit of the Loop in rush periods. It is figured that 100,000,000 passengers will be carried annually by this initial subway system.

The estimated cost of the project now underway is $46,000,000, of which the city will pay $28,000,000 and the Federal Government $18,000,000 under a PWA grant. Chicago's share will come from a traction fund that has been accumulating since 1907 through payments from the traction companies. As a consequence, no additional taxes or assessments are entailed. The tentative program for the future extension of the system contemplates three additional construction stages to add, respectively, 3.60, 18.80, and 20.40 miles. These would bring the total to 50.5 route-miles and would, according to traffic engineers, put a subway line within one mile of 93 per cent of the city's residents. The aggregate cost of this comprehensive network is estimated at $267,000,000. This amounts to about $72 per capita, based on the 1940 population, as compared with per capita expenditures of $75 in Philadelphia and $133, or nearly twice as much, in New York City.

To carry out the work, the Department of Subways and Traction was created in 1938, with Philip Harrington as commissioner and Ralph H. Burke as chief engineer. Last December the name was changed to the Department of Subways and Superhighways, which was charged with the directing of a $205,000,000 program of superhighway construction in addition to the subway plan. As the Federal Government set a time limit of 24½ months for the building of the subway, the 7.7 miles of line was divided into ten tunnel sections, ranging in length from 329 feet to 6,670 feet, and individual contracts were let as rapidly as the detailed engineering plans could be prepared. A list of the contractors, with pertinent data regarding the work that is being done by each, appears below. Twelve more contracts, nine covering the construction of mezzanine stations and auxiliary structures and three that of portals, have been or will be awarded, making 22 in all. Ground was broken for the subway on December 17, 1938, by Mayor Edward J. Kelly and Harold L. Ickes, Secretary of the Interior and PWA Administrator. Five of the tunnel sections have been completed, and work on the others is proceeding at a good rate.

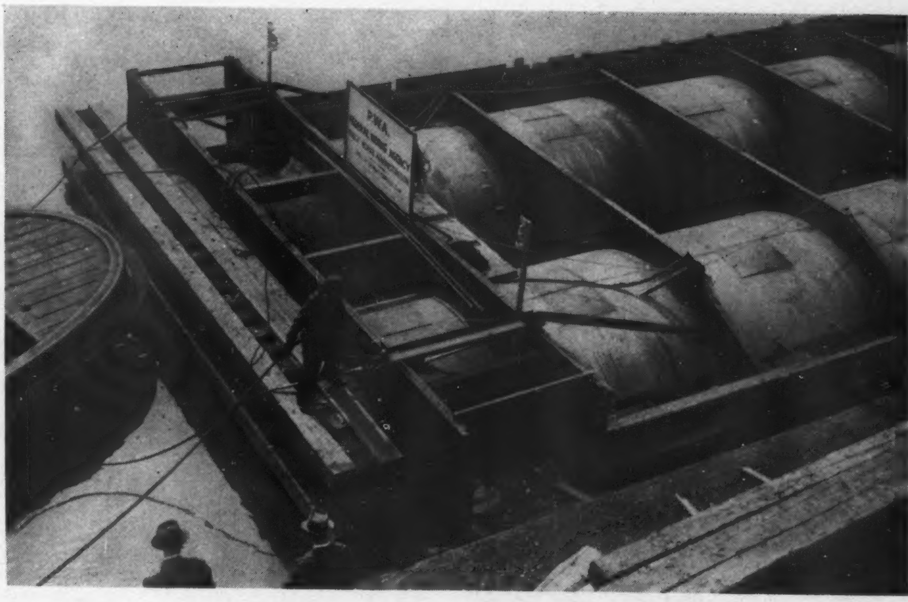
To enable traffic and regular business activities in the streets concerned to continue with a minimum of interruption, it was elected to drive the tunnels underground rather than to use the cut-and-cover method that has been extensively practiced in New York. As the subsurface material consists of plastic clay, it is necessary to support the ground with air under pressure while excavating is in progress. To give it stability as quickly as possible, a primary

List of Contractors for Tunnel Sections

DOUBLE TUBE LENGTH, FEET	PRICE	CONTRACTOR
6,670	$8,212,835.00	Healy Subway Construction Corporation
329	467,663.92	Merritt-Chapman & Scott Corporation
1,099	803,220.50	John C. Tully Company
3,635	2,670,304.50	Herlihy Mid-Continent Company
4,534	2,986,590.00	M. J. Boyle & Company
4,000	2,606,509.60	M. J. Boyle & Company
4,275	6,436,855.00	Healy Subway Construction Corporation
4,212	3,185,789.00	Paschen Contractors, Inc.
3,448	2,094,766.00	John Marsch, Inc.
3,577	2,010,866.00	Michael Pontarelli & Sons
35,779	$31,475,399.52	

steel lining is set up as the tunnels are advanced, and this is followed, as soon as practicable, with a reinforced-concrete lining. This secondary lining is placed inside the steel skeleton, which will remain in position.

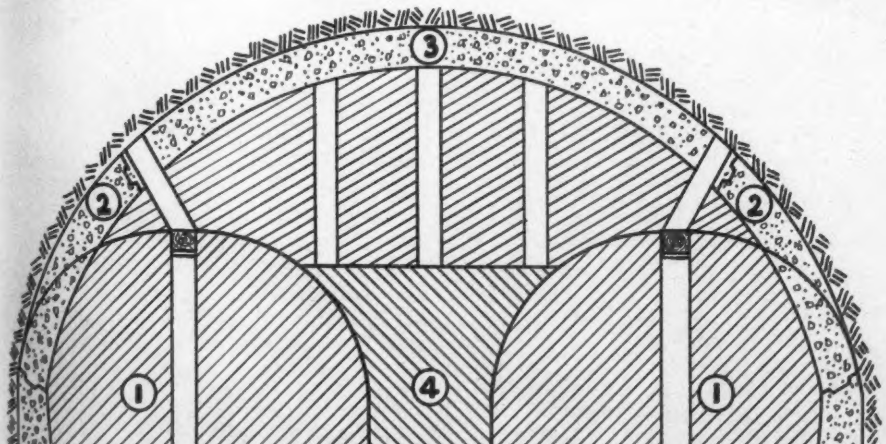
Entrances, mezzanines, and associate facilities, which provide access to stations from the streets, are being constructed by means of openings which are ordinarily 60x80 feet in size. The mezzanines will normally be 19 feet below the street level and will be reached by means of stairways. These as well as escalators will connect mezzanines with loading platforms, which will generally be 39 feet beneath the street surface. The base of the rails will be 6 feet lower, or 45 feet below the street level. All but three of the station platforms are to be of the island type between tracks, the exceptions being those in narrow streets, where there is not enough space available to separate the tracks. In the Loop district the platforms will be continuous on State Street for 7½ blocks, and on Dearborn Street for 5½ blocks. Connecting these two streets there will be four passageways beneath the subways, two for the use of riders transferring from one line to another and two for pedestrians.



RIVER TUBE SECTION

Here is shown a part of the 200-foot twin-tube section that was sunk in a dredged trench to carry the State Street line underneath the Chicago River. The structure is 40 feet wide and 15 feet high, and consists of welded steel plate. It was fabricated by the Graver Tank & Manufacturing Company in South Chicago and towed 18 miles to the crossing site. The contract for this tunnel section was handled by Merritt-Chapman & Scott Corporation.

There are two types of tunnel: one of horseshoe section and the other of circular section, and they are constructed by different methods. The former is advanced by conventional earth tunneling, while the latter requires the use of shields of the kind that has become standard for subaqueous boring. It was at first believed that the entire line could be of horseshoe section; but the moisture content of the clay in the area south of the Chicago River proved to be so great that shield tunneling had to be resorted to there.



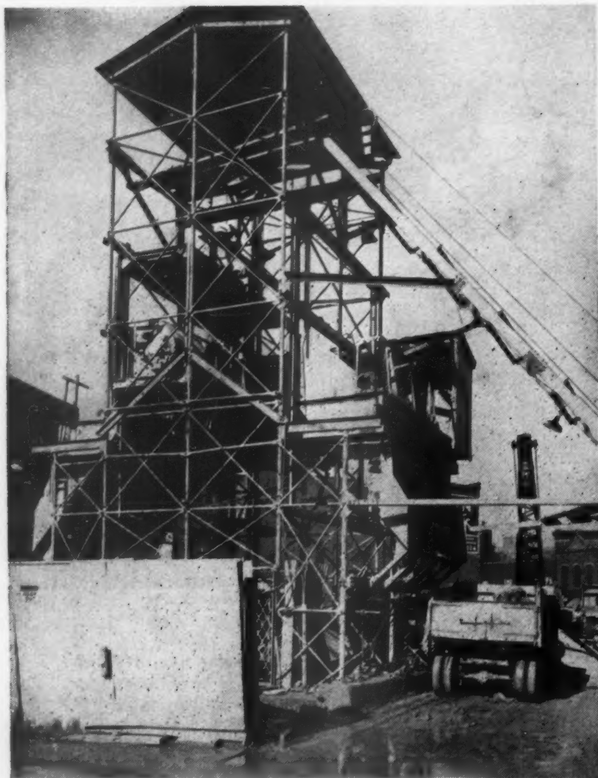
STEPS IN BUILDING CROSSOVER IN TUNNELS

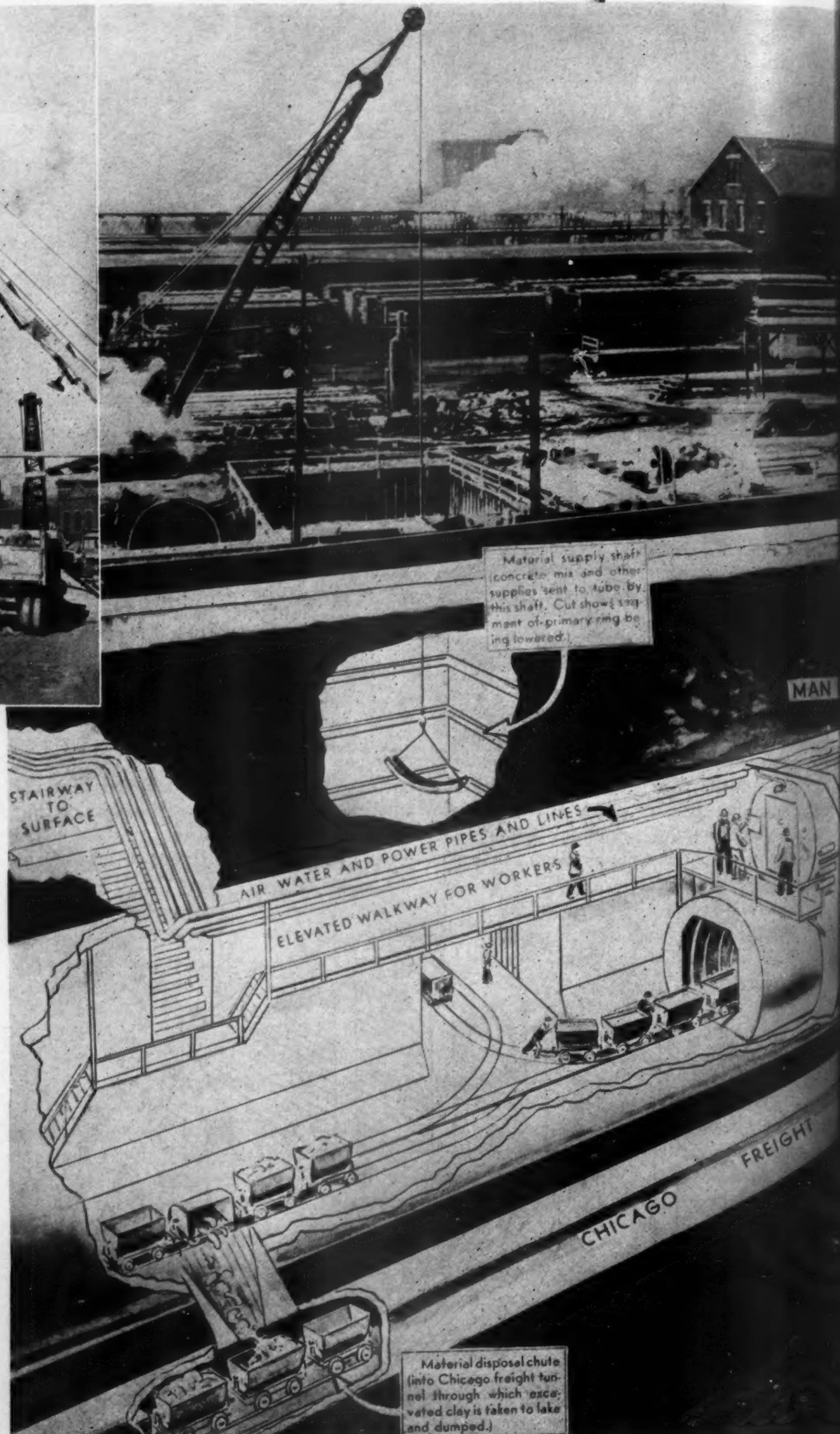
Two adjacent tubes, *1* and *1*, were first excavated in the usual manner, steel ribs and liner plates being set up and the outer or far walls and parts of the inverts concreted. Next the haunch, *2*, at each side of the full-width crossover section was mined and concreted, bracing for the mining and for the concrete forms being supported by the steelwork of the pilot tubes. The crown, *3*, of the larger section was then excavated and concreted, the supports for the bracing and for the forms resting on the bench of clay, *4*, left between the smaller tubes and on the concrete inverts of the smaller tubes. Finally were removed those portions of the ribs and liner plates that did not constitute a part of the wall of the larger section, thus exposing the earth bench, *4*. The latter was then excavated and the concrete invert extended clear across. A somewhat similar procedure is being followed in constructing the stations.

Detailed examination of the subsoil has been made by means of borings at 300-foot intervals along the subway route. Starting at the surface, samples were taken of undisturbed soil by forcing 2-inch Shelby tubing into it and then withdrawing the tubing with its core. With this done, 3-inch casing was driven down into the core hole. This casing was next cleaned out and another specimen taken at the bottom of the hole. By repeating this procedure, a continuous sample of the soil was obtained to a depth 10 feet below the lower level of the subway line. Each of the specimens was marked at the site for subsequent identification and taken to the laboratory to determine its moisture content and compressive strength.

The samples showed that there is a band of soft clay just above the subway line in the area south of the river. The moisture content ranges as high as 50 per cent on South State Street. This extremely soft clay has a compressive strength in some places of as little as 400 pounds per square foot, as compared with strengths ranging from 1,000 to 4,000 pounds for the stiffer material. In addition to these borings, the known behavior of corresponding soil on contracts previously concluded led to the decision to adopt the shield method and a circular tunnel in the clay of high-moisture content. The total length of the shield-driven section is 2.1 miles, or about 29 per cent of the entire subway length.

Save for a few places, the subway is entirely beneath the streets, and it has been necessary to support only a few buildings. The largest of these is the structure housing





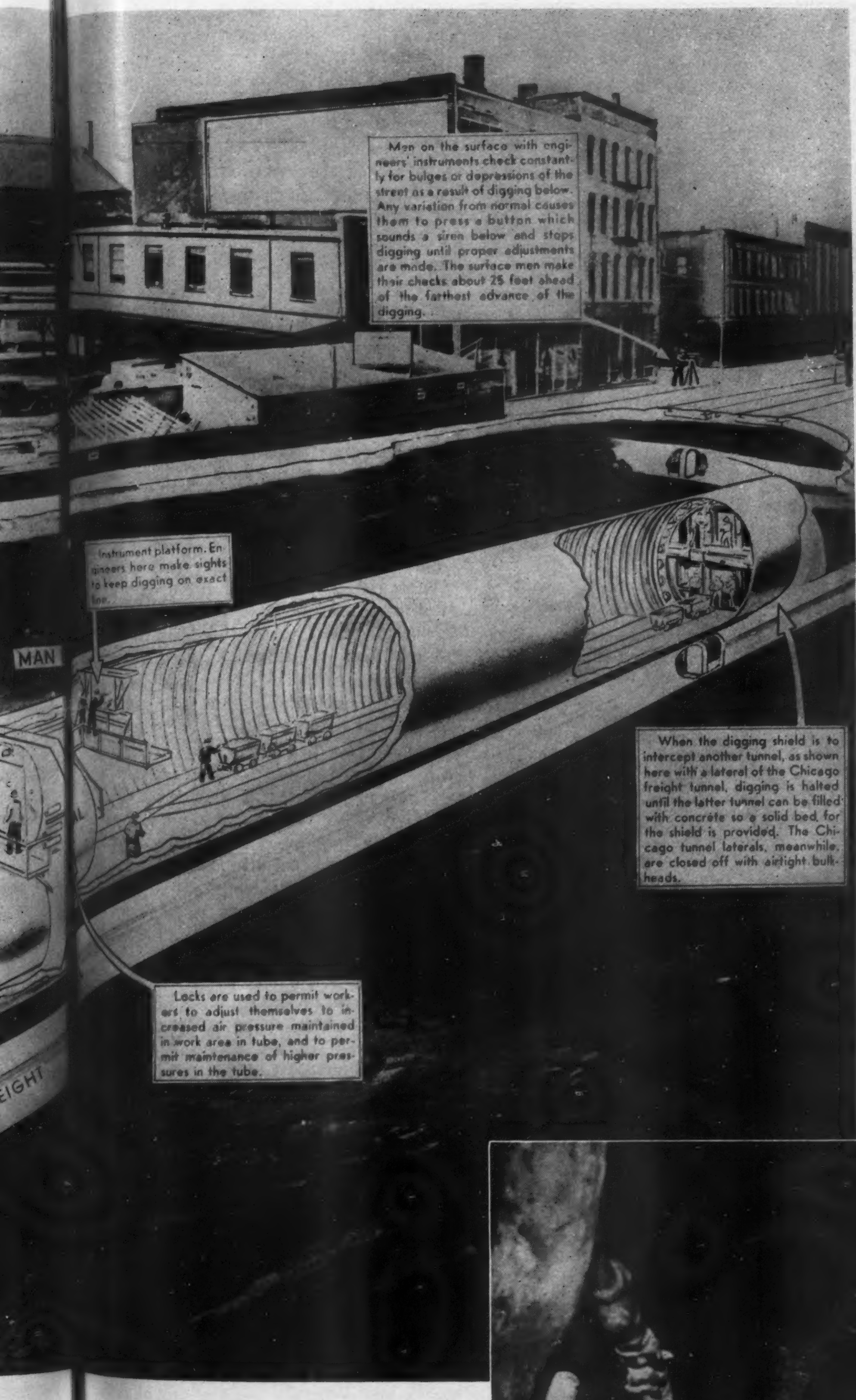
SHAFT HEADFRAME

This structure on the contract handled by John Marsch, Inc., is typical of those in general use. Shafts are approximately 25 feet in diameter and 45 feet deep, and are located on private land adjacent to the subway route. Electric hoists operate two cages for handling muck and materials. The excavated clay is trammed back from the headings, passed through air locks in the access drift joining the subway tunnels with the shaft, hoisted, and dumped into an overhead hopper which loads it into trucks.

the Selwyn and Harris theaters at Lake and Dearborn streets, where the line makes a turn that carries it under one corner of the building. This is in the area calling for shield-tunneling; and the two tubes had to pass between the supporting piers that had been set up. In one instance a shield was successfully pushed through with only 8 inches of clearance on one side. At State and Division streets a 12-story brick hotel had to be shored up. Near the extremities of this route the subway will pass underneath some private property to gain access to streets carrying elevated lines with which connections will be made. At all these locations easements were obtained. On Lake Street, from Canal to Dearborn, a distance of approximately 2,600 feet, the grade of the elevated has been maintained by transferring the load of all columns to jacks.

Structures at or below street level that have to be supported during the construction period include street-car tracks; light, power, telephone, and telegraph conduits; pneumatic postal tubes; and sewer, gas, and water lines. It is incumbent upon the operating companies to take care of these utilities; but, nevertheless, the contractors are required to do a good deal of work to protect them. Manholes and vaults that extend to considerable depths increase the possibility of air escaping from the tunnels, with consequent serious loss of pressure. In one such instance, 360,000 cubic feet of air was lost in ten minutes; but the necessary pressure was maintained in the tunnel by discharging into the workings the full output of all the compressors, including the high-pressure units. To guard against occurrences of this kind, one contractor strengthened the bottoms of all vaults along his section by laying new concrete floors in them and weighting them with sand ballast.

In general, there has so far been little visible evidence at street levels of the operations going on below. Some minor heaving of the surface has been experienced in the



SET-UP FOR DRIVING SHIELD SECTION

This diagrammatic wash drawing was prepared by Otto Marker, an artist on the staff of the *Chicago Daily News*, and is published through the courtesy of that newspaper. It shows what might be called an ideal section, in that the disposal of muck is made easy by the proximity of the Chicago Freight Tunnel. The location is State and Taylor streets.

make use of shields in the softer material.

Contractors for the horseshoe sections gain access to the subway line by sinking shafts. These and the compressor houses and other requisite structures are all situated on private land adjacent to the subway route. Shafts are approximately 25 feet in diameter and 45 feet deep, and are supported by steelwork consisting of I-beam rings with liner plates behind them. Over each shaft is a mine-type steel headframe and muck hopper. An electric hoist with two cages handles muck and materials. Men are not allowed to ride these cages: they reach the workings by means of spiral stairways. Extending from the bottom of the shaft to the subway line is a drift, generally about 12x15 feet in section and lined with concrete. It contains two combination man-and-muck locks which are usually long enough to accommodate six or more cars at a time. Lines for high- and low-pressure air, water, power, and telephone service are carried through the locks and are provided in duplicate as a safety measure. Substantially all the compressors are

TUNNEL SWALLOWS TUNNEL

At a number of places the new subway intersects the Chicago Freight Tunnel, a 42-mile-long underground railway that has served downtown Chicago since 1912. On State Street it is being blasted out ahead of the workers as they proceed. This picture, taken at Milwaukee Avenue and Canal Street, shows workmen demolishing the smaller bore with air-operated paving breakers.

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horseshoe sections, but this soon subsided after the concrete lining was poured. It was apparent, however, that there would be marked and perhaps even serious disturbances if an attempt were made to apply the horseshoe tunneling method in the extremely soft clay south of the river; and it was largely because of the experience gained in driving through the stiffer ground on earlier contracts that it was decided to

CLOSE VIEW OF SHIELD

South of the Chicago River the blue clay is so soft as to require tunneling by the shield method. Four such structures are in service. Each weighs 225 tons and is nearly 25 feet in diameter. This rear-end view shows the six working compartments in each of which two or three men cut slabs of clay from the face and pass it back for loading into cars. The large horizontal member just below the center is the erector arm that handles the steel-lining segments of which a ring is placed after each shove of the shield. Around the arc at the top may be seen several of the twenty-four 200-ton hydraulic jacks by means of which the shield is advanced. The shield shown is being used by the Healy Subway Construction Corporation.

electrically driven and, as a safeguard against failure, are supplied with power from two independent generating stations of the Commonwealth Edison Company. Each contractor is called upon to have a standby compressor plant of sufficient capacity to meet the entire low-pressure-air requirements. The average pressure maintained in the workings is 12 pounds, while 105-pound air is usually furnished for operating tools and other equipment.

The general mining procedure in the horseshoe-section tunnels is to drive two side or wall-plate drifts at the spring line in advance of the heading. In each of these is placed an 8-inch H-beam which is supported at its rearward end by a 6-inch H-beam post and at its forward end by wooden blocks. Excavation of the heading then proceeds by the benching method, the clay being taken out in three lifts. As the top bench is advanced, arch ribs, each consisting of three pieces of 6-inch H-beams or 7-inch I-beams bolted together, are set on the wall beams to hold the roof firmly. They are approximately 2 feet apart, and between each adjacent pair are placed corrugated liner plates 2x4-feet in size and $\frac{1}{8}$ inch thick. On all but one contract they are bolted to the webs of the arch ribs, and the ends of abutting plates are bolted together through turned-down flanges. One contractor has successfully used plates without flanges that rest on the outer flanges of the ribs. As the bottom bench is pushed ahead, posts are set under the side beams at stated intervals.

Practically all the clay is being excavated with power-driven knives, the construction of which is shown in an accompanying drawing. Up to six knives are used in a heading. Each is operated by an air-motor hoist mounted well above the floor and from 30 to 50 feet back from the heading. The cables running from the hoists to the knives pass over sheaves at the sides or top of the tunnel, depending on the direction in which it is desired to cut. With these knives the miners speedily slice large slabs of the stiff blue clay from the working faces. The pieces are caught by two muckers and thrown into a $^2/_3$ cubic-yard car. Trains of loaded cars are pulled back from the heading by storage-battery locomotives, passed through a lock, and hoisted to the surface, where they dump into a hopper for loading trucks. The latter haul the muck to the nearest point on the Chicago River from which it can be taken in barges to disposal areas along the front of Lake Michigan, where considerable areas of usable land are being built up.

As soon as the primary lining is in place, pebble grout is poured behind it to fill voids and to prevent settlement of the clay. The grout is shot through holes in the liner plates with pneumatic equipment, and pressures up to 25 or 35 pounds are used. Lining of the tunnel with 20 to 28 inches of reinforced concrete follows close behind excavating. Although the operating sequence varies, most contractors mine 30 feet one day and line it the following day. As they drive two headings in the same direction it is possible to alternate the work and thus to keep both mining and concreting gangs occupied all the time. In most instances, the access drift is near the center of the contract section and headings are opened in both directions, making four in all. Under the plan outlined, muck comes from only two headings at a time and can be handled readily, whereas if three or four headings were mucked simultaneously the locks would be incapable of passing it. One contractor who is advancing only two headings mines continuously, with the exception of halts of two or three hours at intervals to pour 30 feet of invert. As soon as this is in place, it is bridged over and tracks are laid on the temporary flooring so that cars can be moved to and from the heading. Every second day he pours 60 feet of arch. The daily progress in each bore is therefore 30 feet, as compared with 15 feet for the system of alternate mining and concreting.

Concrete is not lowered through the shafts, but is usually "locked down" from the street through pipes. Aggregates and cement, properly proportioned, are hauled to the respective lock sites, where the concrete is mixed in a conventional-type paver and discharged into a hopper above the air lock. From there the batch moves by gravity through a 12- or 14-inch pipe to a car-mounted hopper in the tunnel below. It then flows to either a concrete pump or a pneumatic placing machine for delivery to the forms under pressure. In some in-

stances, concrete pumps are located at the street level. The surface concrete stations are moved ahead from time to time as the work progresses, the distance between points of use ranging from 250 to 1,000 feet.

The forms employed for concreting the arch are of the regulation collapsible type that travels on rails, and they are made up of sections 5 feet long. Ordinarily there are six sections in a form, giving it a length of 30 feet. However, forms up to 65 feet long have been used. Only curb forms are required in pouring the invert, the material other than that being placed directly against the primary lining and the ground. As soon as the concrete has set, cement and sand grout is poured behind it through pipes previously placed in the lining for that purpose. The tubes are designed to withstand the maximum combined weight and lateral pressure of the material penetrated. The load of the overlying earth is figured at 100 pounds per cubic foot, plus the live load of the street which is computed to be 300 pounds per square foot, while the lateral pressure is estimated to be from one-third to two-thirds of the vertical load.

The shield-driven sections are all included in two contracts, and a generally similar procedure is being followed on both. The primary lining is much heavier than that used in the horseshoe sections because it has to withstand the thrust of the shoving jacks. Individual segments are 33 inches wide and of such lengths that seven of them, together with a keyway, constitute a complete ring weighing 1,750 pounds. Each shield, of which four are in service, weighs 225 tons, is $19\frac{1}{2}$ feet long, and has an inside diameter of 24 feet $10\frac{1}{2}$ inches. The skin plates are $2\frac{1}{2}$ inches in aggregate thickness and are riveted together. The upper half of the cutting edge extends about 4 feet beyond the lower half, forming a protective hood. The shield interior is divided into six compartments by horizontal and vertical bracing members about 6 feet back from the front of the hood. The sizes of these openings can be controlled by adjustable H-beams. Jacks for breast boards are provided, but it has not been necessary to use them. The shields were lowered from the street to the tube level through large openings formed by driving H-beams and placing lagging behind them. When they have finished their allotted tasks they will be cut up and removed in sections.

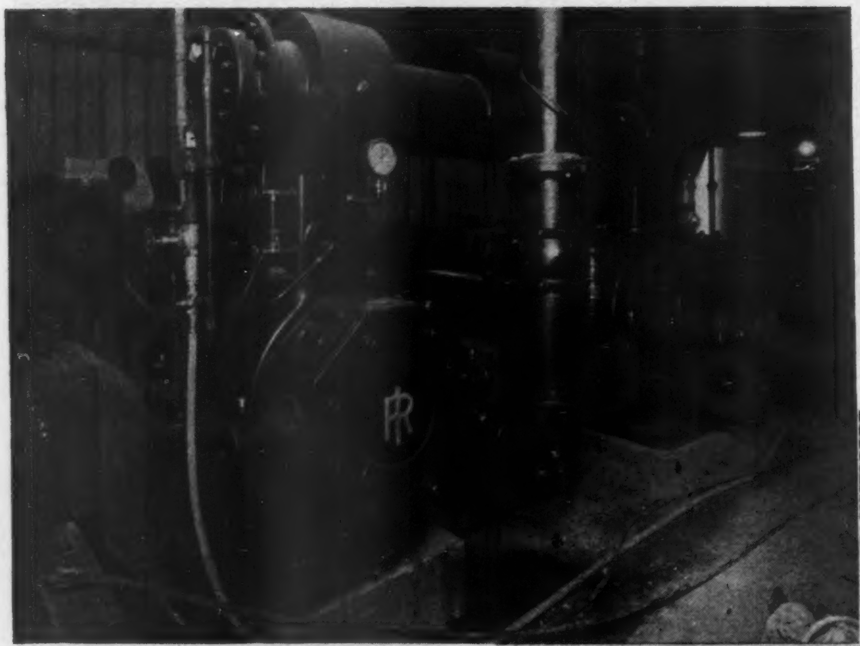
In the circular tunnel the whole face is necessarily mined, eliminating benches. The shield is advanced 33 inches with each shove, the power for the movement being applied through twenty-four 200-ton hydraulic jacks arranged at equidistant points around the rear end of it. These bear against the last-placed ring of lining. The plastic clay flows through the openings in front of the shield with about the consistency of tooth paste. Two or three men work in each of the six compartments, cutting the material off with wires and into pieces that can be readily handled. These are passed back and loaded into cars which are pushed on to a siding by workmen. Trains thus formed are hauled out by storage-battery locomotives.

The muck is disposed of through the Chicago Freight Tunnel, a system of concrete-lined galleries 6 feet wide and $7\frac{1}{3}$ feet high. This underground railway, opened in 1912, extends for 42 miles and is 40 feet beneath the surface. It has been used for many years to deliver freight to and to remove garbage, ashes, etc., from downtown Chicago. It was built by private capital, but is now owned by the city. The new subway lines will cut it in a number of places, and on State Street it is being blasted out as the workers proceed. The future usefulness of the system will be impaired by the operations now in progress, although sections of it will remain in service. Regular 4-cubic-yard cars of the freight line are carrying the muck from the new bores. They are pulled through the freight tunnel to the river by trolley locomotives, and their contents are loaded on to barges for disposal.

After each shove of a shield, another ring of lining is added. The segments are hauled

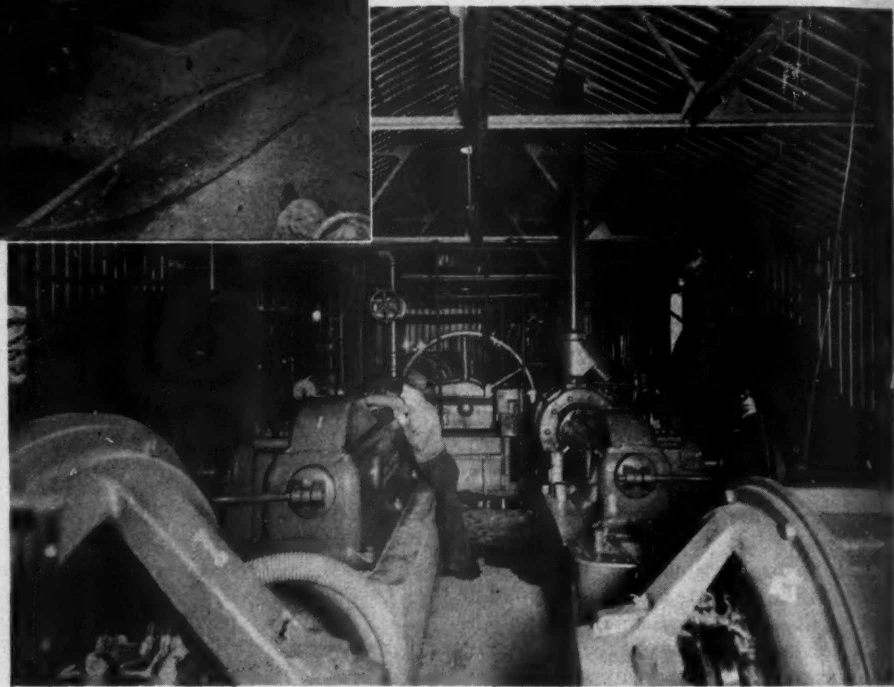
"LOCKING DOWN" CONCRETE

Concrete for lining the tunnels is not sent down the shafts but is delivered through air locks. The upper picture shows one of the surface plants. Aggregates and cement, properly proportioned, are fed to a paver, where water is added and the concrete is mixed. It then goes to a hopper (in the wooden housing at the right) from which it is "locked down" through a pipe to the workings below. The lower view shows the receiving facilities underground. The concrete is discharged into a hopper that feeds it to a pneumatic placing machine. This, in turn, forces it through a pipe line to the heading. Instead of pneumatic equipment, some contractors use concrete pumps located either underground or on the street level. The surface equipment is moved ahead from time to time as concreting proceeds.



COMPRESSOR PLANTS

Each contractor has high- and low-pressure compressors, and the latter must have an aggregate capacity of twice the normal requirement to make sure that the pressure within the tunnels will be maintained in case of leaks or emergencies. Most of the units are electrically driven and are provided with two independent sources of power supply. At the left is an Ingersoll-Rand Class PRE 16-inch-stroke machine used by the Herlihy Mid-Continent Company. Below is a view of the plant of Paschen Contractors, Inc. In the foreground are two belt-driven I-R compressors. The one on the left has furnished air for ten foundation jobs since it went into service in 1923.



to the rear of the shield in cars. There they are lifted off, one at a time, by a cable attached to an overhead air hoist and brought up to the erector arm. The arm picks the segment up by the T stiffener welded to it, moves it to its allotted position, and holds it there while it is being bolted. The hydraulic jacks in that particular zone are retracted to allow the segment to be placed. As soon as that is done, they take up their new positions and bear against its forward face. Each of the four shields averages about 36 feet of advance a day. The maximum has been 46 feet. It is not necessary to calk the joints between the lining segments because the surrounding clay does not lose its moisture content. Pouring of the concrete lining in the circular tubes follows about 500 feet back of the heading to make certain that the strain on the steel lining from the shoving does not crack it.

The State Street line will run under the Chicago River and the Dearborn Street line under the South Branch of that stream. Below Lake Street, the latter section was driven by the same method used in the case of the horseshoe-shaped tunnel, and was successfully pushed through a cluster of old piling and the center pier of a former swing bridge. Special construction methods had to be adopted for the State Street underpass, for it was necessary to keep the line at the highest possible elevation beneath the river in order to meet the grade at the station between Randolph and Lake streets, two blocks south of the underwater section. This was done by sinking two prefabricated steel tubes of horseshoe shape into a dredged trench. This twin-tube section is 200 feet long, made up of 5/16 inch steel plate and covered inside and outside with reinforced concrete. In the South Chicago drydock, where the unit was built, the concrete lining was poured in its entirety, while the outside coating was applied to a point 16 feet 9½ inches above the invert. This, it was calculated, would give the tubes the desired buoyancy for transporting them to the trench. With their ends bulkheaded, they were towed 18 miles to the crossing site, floated over the trench, and sunk by weighting them with precast concrete blocks. They were then maneuvered into final position by two derrick scows with open wells through which cables that were slung around the tubes passed to donkey engines on the deck. They were lined up by transits sighting on targets on each side of the river and one in midstream. The scows were moved by means of cables extending to moorings on all sides and wound around the drums of donkey engines on the craft.

Prior to lowering the tubes, cofferdams had been provided on opposite sides of the river, and in them were built transition sections to be connected with the sunken tubes. Just outside the cofferdams, at the two ends of the trench, landing platforms were constructed on piles so that the ends of the tubes would come to rest at the exact elevations desired. Once the submerged section was in position, divers went down to pour concrete collar seals between them and the adjoining cofferdam sections. The upper part of the outside concrete covering was then poured through tremies and the trench backfilled. There is only a 5-foot layer of earth over the tubes. As the bridge across the river at this point was in bad condition, advantage was taken of the cofferdams to build a new one. The wooden piling on which the old structure rested was torn out, and caisson footings for piers for the substitute span were poured.

At three points in the subway are being provided crossovers for trains from one track to another. These are all in the horseshoe-shaped section and are 180 feet long. One contractor did this work in the tunnels, while the two others are doing it in cofferdams. These structures are of great size, being approximately 191 feet long, 44 feet wide, and 46½ feet deep. They are being constructed by driving H-beams on 5-foot centers and placing lagging behind their flanges. One of the contractors made the building of the cofferdam his first aim, and then located in it his tunnel-driving plant.

In addition to Commissioner Harrington and Chief Subway Engineer Burke, the directing personnel in charge of the work for the Department of Subways and Superhighways consists of A. M. Crain, engineer of subway construction; P. F. Girard, engineer of subway design; R. S. Knapp, assistant subway engineer in charge of surveys.

Rayon

the Modern Textile

Philip H. Kline

MILADY IN RAYON

Clothes may not make the male, but they certainly enhance feminine loveliness. These pictures show costumes fashioned of Enka rayon-yarn fabrics. At the left are mermaids in Gantner floating bra suits; at the right is a Jantzen dressmaker bathing suit in a satin-knit; and at the top are creations of Sage crepe—wide-skirted pajamas and a youthful dirndl dress.

THOSE who have observed the progress of the rayon industry have described its growth as amazing, phenomenal, or incredible. They have viewed the rapid rise of world production and consumption of this new fiber from about 2,000,000 pounds in 1900 to around 26,000,000 pounds in 1918 and to nearly 350,000,000 pounds in 1928. A dozen years ago very optimistic predictions were made for the future of the industry. Technical difficulties were being overcome, capital was more than ready to participate, and the commercial trade was getting just recognition from the processing plants and from the consumer. One survey bureau foresaw a production of 500,000,000 pounds by 1933, and an informed writer, M. H. Avram, dared to predict an output of 1,000,000,000 pounds by 1939. Actually, the billion mark was passed in 1935, and the Commodity Research Bureau, Inc., has estimated that the 1939 world production was 2,150,000,000 pounds!

Yet this textile did not have the field that was open to such innovations as the radio, aeronautics, or motion pictures. It had to compete with 5,000-year-old sericulture —silk from silkworms, and it had to work in the same trade channels with cotton that had been known in India in 500 B. C. and with wool that had been used since earliest biblical days. The demand for rayon today is probably more than five times that of silk. Of the total consumption of the four leading fibers in 1936, cotton made up about 82 per cent, wool 9, rayon 7.6, and silk 1.4 per cent. Considering the modernity of rayon, it is challenging to find out just what is behind this remarkable textile.

Years of contemplation, research, and disheartening ventures form the background of the modern viscose plant such as is described in this article. Even the naming of the product met with difficulties. "Artificial silk" just didn't take the public's fancy. It sounded inferior, it might be a poor substitute; and after all silk was a regal textile, not to be imitated. But just as the developers of this synthetic material were relentless in improving it, cautious with their trade secrets, and careful of their financial control, so were the yarn makers ingenious in coining a pleasant-sounding word—rayon—under which they could market their product. It was highly suggestive of the material: bright like a beam of light, yet soft at the end like a rippling reflection.

According to the technical definition, the word rayon denotes, essentially, typical filaments derived from chemical solutions of cellulose which have been pressed through very fine holes and then solidified by the necessary reactive agent. Contrary to the early popular conception, it is not

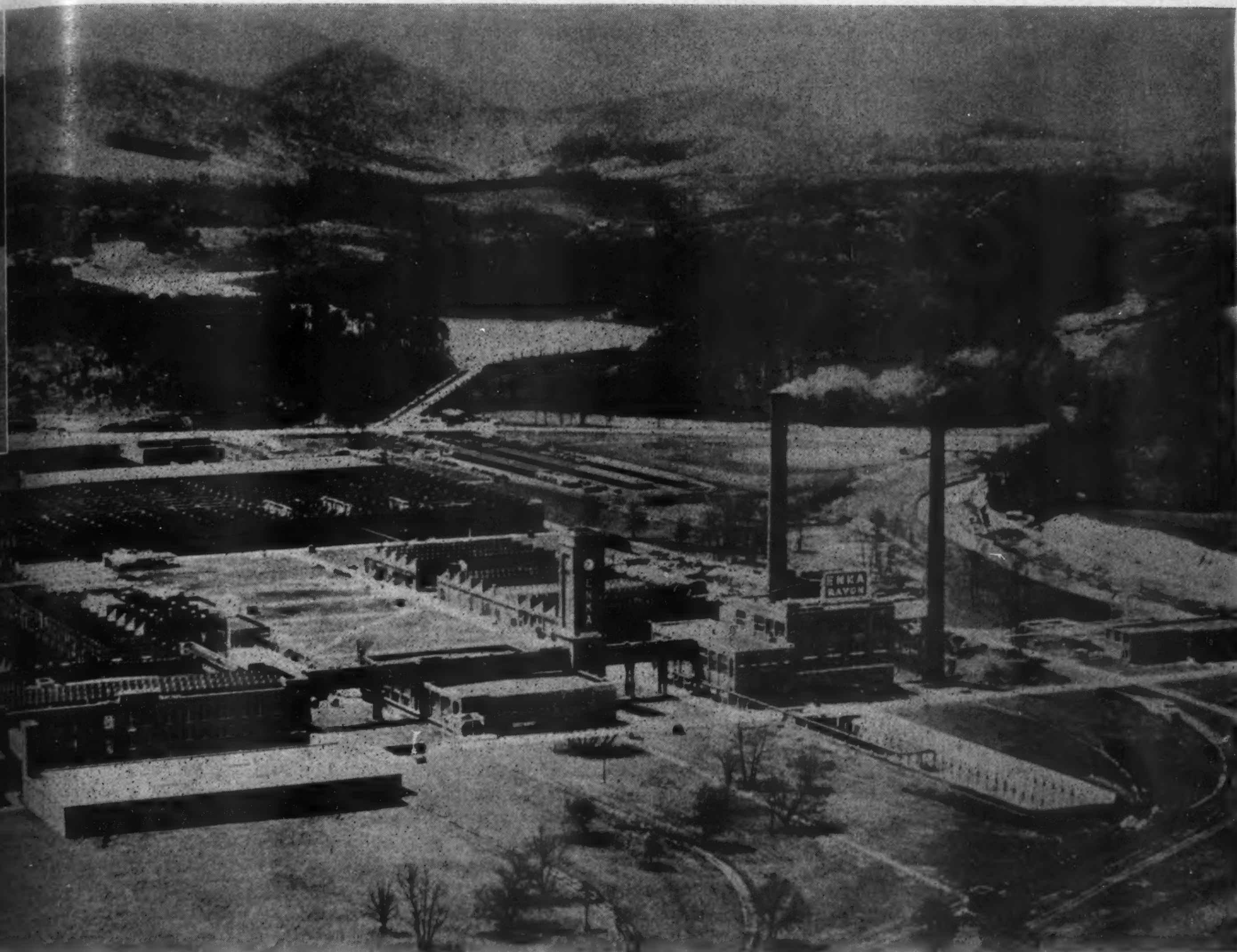
SCENES IN ENKA

The Village of Enka has been built along the shores of a 75-acre lake in a picturesque setting of native trees and shrubs. These views show a section of the lake, the clubhouse that is maintained for employee activities, and one of the homes with dogwood in bloom.

always a bright lustrous textile; but, along with its allied fabrics, it is now used for a wide variety of products ranging from sheer underthings to heavy outer garments, elastics, luggage cloth, wall "paper," transparent wrapping sheets, and book bindings.

The material is always called "yarn" in the textile industry; but it is not necessarily in the form of soft bulky skeins that many of us might picture ourselves holding on upraised arms for our mothers to roll into balls. As it comes from the rayon plant, the yarn has many degrees of twist, luster, and windings, depending upon the requirements of the weaving or knitting mills that fashion it into fabrics or articles for the consumer. Inasmuch as it is a chemically controlled product and not one of Nature's varying and impure forms, any one of a wide range of fibers can be made with uniformity and with seemingly unlimited combinations of sheen, feel, and texture to meet specific needs.

Rayons of varying chemical compositions



PLANT OF AMERICAN ENKA CORPORATION

This viscose-process rayon factory near Asheville, N.C., has a daily output of 70,000 to 80,000 pounds and employs 2,800 persons. From the warehouse in the left foreground, sheets of wood cellulose go to the first chemical-process building immediately behind. Beyond it are the departments where the viscose is made into yarn. The huge wing in the background houses the twisting, winding, and packaging departments and the main offices. At the right are the power house, shops, and water-filtration plant. Enka, a company-built village, lies along the shores of the lake beyond the buildings.

are produced, with the result that some will react to dyes that do not affect others. With silk that takes still different dyes, cloth can be woven of a combination of these yarns and exposed to more than one color, each absorbing the dye for which it has an affinity. This treatment, called cross-dyeing, has increased the use of rayon and made it possible to create new fabrics. In fact, allied products made of similar solutions and by kindred processes are gaining recognition rapidly, and some persons in the industry have great expectations for one of them—"staple fiber." It is mixed with other fibers, the textile being known as spun rayon. Oddly enough, this material has no use for the continuous yarn required for ordinary rayon. Instead, the filament is chopped into short, even lengths or staple fiber.

What the pioneers in this field would think about these short fibers is hard to imagine; but they would undoubtedly be surprised, because they were all looking for a long, continuous filament. As early as 1664, Robert Hooke, an English physicist, published in his *Micrographia*: "Probably there might be a way found out, to make an artificial glutinous composition, much resembling, if not full as good, nay better then that Excrement, or whatever other substance it be out of which the Silkworm wire-draws his clew...... I need not mention the use of such an Invention, nor the benefit that is likely to accrue to the finder, they being sufficiently obvious."

Later, about 1742, Rene de Réaumur pointed towards silk as the only liquid gum that had been dried. Varnishes were said by Réaumur to possess the essential qualities of silk, for he wrote—"If we had threads of varnish we could make them into fabrics which by their brilliancy and strength would imitate those of silk, and which would equal them in value, for good varnishes when properly dried have no smell."

However, no practical experiments were conducted until 1855, when Audemars, a chemist in Lausanne, Switzerland, obtained a patent in England on a process for making artificial silk. Because mulberry leaves were the main diet of silkworms, he took the fibers from a mulberry tree, dissolved them in nitric acid, and produced cellulose nitrate. This he dissolved in alcohol and added a gum so that the solution would have the properties of real silk. It is said that he tried, by dipping needles in the solution and raising them, to form finely drawn out filaments; but his efforts were not rewarded with silk.

The idea was germinating; but only a few laboratory contributions had been made by various persons up to 1860, the year in which Sir Joseph Swann produced an artificial fiber in much the same manner as just described, but with one vital exception: he forced the solution through fine holes into a bath which coagulated the threads. He was looking for a filament that he could carbonize for use in the electric

incandescent lamp then recently invented by Mr. Edison, and definitely established the fact that a continuous fiber could thus be made. The cellulose nitrate, which is now known as guncotton, was washed in solutions to remove the danger of fire; and though the filaments were actually woven into fabrics, they obtained but little commercial recognition. Many other scientists of that period made important contributions to the art; but of all the methods only four were found to be practicable.

Experts acknowledge the "Father of Rayon" to be Count Hilaire de Chardonnet, who was a pupil of Pasteur at the time of the latter's silkworm-disease investigations and planned the first complete mill procedure. By 1891, Chardonnet had so far improved his process that he persuaded financial interests to establish the first nitrocellulose rayon plant.

Instead of nitric acid, another chemist, E. Schweizer, found, in 1857, that a copper-alkaline reagent would dissolve wood pulp. This was developed by Depeisses into the cuprammonium process, which was patented by him in 1890; and Dr. E. Elsaesser featured a stretch-spinning method by which filaments of especial fineness can be obtained and for which the cuprammonium process is suitable.

As early as 1843, John Mercer used caustic soda to treat cotton fabrics, resulting in what is known as mercerizing. From that, C. F. Cross and E. J. Bevan, and later associates, also in England, developed the viscose process of producing cellulose fibers. Working with these men in an effort to make light-bulb filaments, C. F. Topham originated the spinning box. This important device provided a means of collecting the yarn, and gave to the mills the nearest thing to a cocoon that had yet been invented.

Subsequently, from about 1894 to 1902, satisfactory cellulose solutions were made by an acetic-acid treatment. By dissolving the resultant acetate in acetone, a varnish-like substance of low inflammability was produced. This was manufactured and used in England to "dope" airplane wings, Doctors Camille and Dreyfus having gone from Switzerland to England to promote the preparation. The acetate method of making textile filaments came into being at the end of the World War, and was brought to America around 1924. In the meantime, the nitrocellulose and viscose processes were started in the United States. A cuprammonium plant was not introduced in this country until about 1933.

The original nitrocellulose process has now become practically obsolete through the establishment of more economical methods; but, like in the case of the three others, the raw material consists of wood pulp or cotton linters. Generally, these are more than 50 per cent cellulose and are carefully selected and made ready for the chemical solutions. Pulpwood is chipped, cooked in a solution of sodium sulphite for about fifteen hours, and thoroughly washed. The screening, bleaching, and preparation are similar to the treatment it receives in paper making, except that greater emphasis is laid on uniformity and purity of the processed sheets.

Cotton linters are short fibers left on the seed after ginning. Each batch for rayon stock is carefully analyzed and watched during the digesting period. Driers extract the wash water from the product, which is also made up into sheets and baled for the industry. Cotton linters were principally used in the nitrocellulose process. They were treated with nitric and sulphuric acids and washed to form nitrocotton. This was dissolved in alcohol and ether, yielding a collodion. After filtering through cotton, silk, and wire cloths, the solution was aged and stored. At the proper time it was ejected through jets to form filaments, the alcohol and ether being evaporated in a current of warm air directed over the yarn, thus solidifying it and allowing it to be wound on bobbins or twisted into skeins on glass rods. As this material was still a nitrocellulose and highly inflammable, it was denitrated by an ammonium or sodium-sulphide bath for about two hours, after which it was washed, graded, and packed.

In the cuprammonium or cuprate process, atomized copper hydrate is introduced into the cellulose product in a closed chamber. Next ammonia is added to the mass in a kneading machine, where it is reduced to a viscous state. After thinning with water and filtering it to prevent broken threads and fibers of uneven texture, the material is passed to a spinner. Pumps closely control the amounts of the solution that are forced through fine orifices in spinnerettes immersed in a setting bath of warm water. This bath absorbs part of the copper and ammonia and allows the yarn to be placed on bobbins or in a spinning box, which will be described later. Cold sulphuric acid is then used for a second wash. Treatment for softening, drying, and fluffing makes the yarn ready for wrapping and shipment.

The two methods just mentioned, and the viscose process that will be taken up in detail later, all provide yarn suitable for the needs of the textile industry by regenerating the cellulose in the raw product. However, in cellulose-acetate yarns, a newer and fast-growing variety, advantage is actually taken of a chemical change of the compound into cellulose acetate. This imparts particular properties to the yarn, or to other forms into which it is made, and permits it to be used for specialties or unusual fabrics.

The original cellulose is prepared by washing, bleaching, and drying until it has a moisture content of not more than 5 per cent. Acetic-acid compounds and sulphuric acid or other reagents serve to dissolve the raw material in enamel-lined tanks and convert it into cellulose acetate in the form of a white, fluffy precipitate in water. Further washing and drying get it ready for the acetone treatment, which reduces it to "dope" or spinning liquor. This solution is dry spun—that is, it is not passed through a liquid bath to congeal it but is led through a current of warm air which evaporates the acetone. At the bottom of the tube conveying the warm air, the filaments are collected on a revolving bobbin from which they are usually twisted and prepared for the trade by winding them off on to cones or into skeins. It is worth noting

LOCATIONS OF RAYON PLANTS

Sites of the principal United States plants, with relative capacities indicated by the sizes of the dots. It will be noticed that a great many of the mills are located in the Appalachian Mountain system. The United States production of rayon and rayon staple fiber in 1939 was 384,200,000 pounds. The greater proportion of this was made by the viscose process.

TRUCKS AT NOVEL LOADING PLATFORM

Loading platforms have an effective setback arrangement to permit diagonal parking of the 8-ton trailer units that do much of the hauling. Box cars and trucks were formerly loaded from parallel platforms, and rail shipments are still handled in that manner. Owing to the increase in transportation by truck, the arrangement shown was devised to lessen loading time and to prevent congestion.

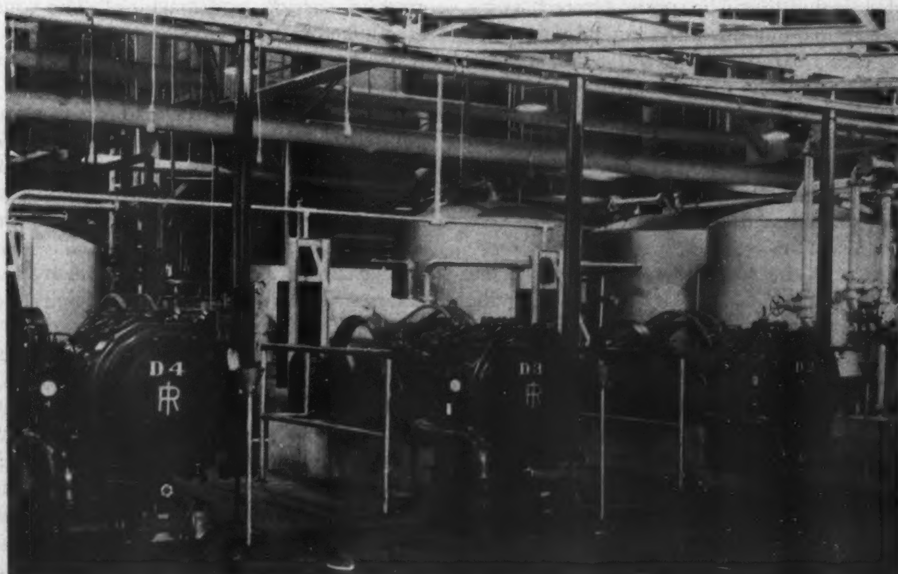
that the yarn thus produced is nearly two-thirds heavier than the original linters or pulp that has gone into its production. A feature of this process is that there is no waste, because unused material can be redissolved and reused. By the cuprate method the waste is reported to be as low as 0.5 per cent and by the viscose process up to 4.5 per cent. Not all of this is dead loss, however, for imperfect yarns are often used with other fibers in multiple weaves.

Sites suitable for any rayon plant must have the following features: the ground should be level, preferably about 1,000 feet above sea level, and usually more than 50 acres in size. An ample daily supply of clear soft water that meets the rigid specifications is a prerequisite, as well as a waste-water channel fed by a stream with a sizable drainage area. Coal within a certain price limit must be available, and proper railroad facilities are needed. A stable labor situation should prevail, and a fair-sized urban population should live nearby. These factors led to the selection of plant locations similar to those in the Appalachian valleys, though the first commercial establishments were nearer the northeastern seaboard. More recently plants have been moved to or been erected in the southern highlands, and large companies that have entered production since 1925 have chosen sites in the South, as shown on the accompanying map.

Among such modern plants is that of the American Enka Corporation, near Asheville, N. C., which manufactures about 70,000 to 80,000 pounds daily by the viscose process. P. Paul Kriek, chief engineer for Enka, has supplied the following outline of the major plant arrangements. Wood pulp shipped in from Canada and the west coast is the basic raw product. This comes in 25x32-inch sheets, and is handled in bales by storage-battery tiering trucks working in storage warehouses. When needed, the pallets holding the bales are carried to the third floor of the viscose building, where the sheets are placed edgewise in large open vats for treatment with caustic soda. This starts the chemical processes, the materials for which are entirely of domestic origin and many of which are recovered for reuse. A large amount of carbon bisulphide is required, and many acids are stored and mixed in nearby vessels. In the course of reclaiming some of the acids, an important by-product is obtained in the form of sodium-sulphate crystals which are shipped to paper mills.

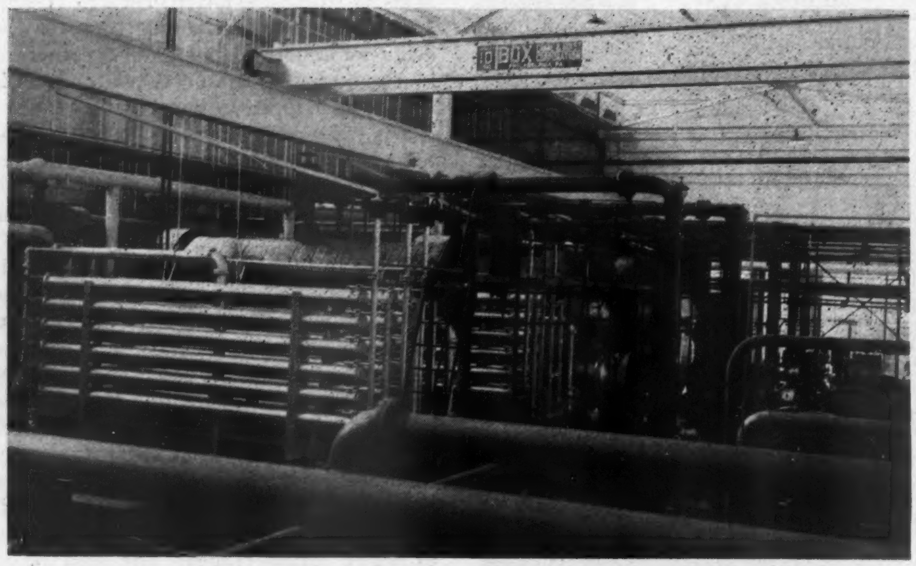
The wood-pulp sheets become thoroughly soaked in the soda solution after a matter of hours. Then they are passed through horizontal presses to remove the excess alkali, ground into flock or "crumbs," kneaded in a mixer similar to a large bread-dough machine, and placed in aging tanks, where an even temperature is maintained for a few days. Next the containers are transported to a point above the xanthate drums. Xanthate is the trade name for this cellulose after it has been treated with carbon bisulphide. Horizontal drums receive the flock, which is white, and revolve slowly while the carbon bisulphide is added. Utmost care is taken in handling this highly explosive liquid reagent, the feed being controlled by oxygen-free gas under moderate pressure. The crumbs then turn an orange shade and can be dissolved by a weak caustic solvent, making the spinning material or viscose. The solution is aged further, mixed again, and forced by compressed air through filter presses to remove every possible impurity that might affect the spinning of the yarn.

Throughout all this chemical treatment the utmost caution is exercised, and thorough analysis is made of the product at every step. The laboratory makes careful tests of the runs of the material, and experienced technicians and chemical workers constantly observe instruments to control and sometimes to record temperatures, pressures, and other characteristics. These instruments are air-motivated by means of automatic orifices that open and close ac-



VACUUM PUMPS

During the latter part of the period during which viscose is being aged for spinning, it is kept under a partial vacuum. This is done to extract air bubbles from it and to guard against breakage of the continuous, fine filaments issuing from the spinnerettes. Vacuum for this and other purposes is supplied by three Ingersoll-Rand Class ES 22x9-inch vacuum pumps.



COMPRESSOR ROOM

The principal use of compressed air is for forcing the viscose solution through filter presses prior to spinning in order to remove impurities. It also controls instruments and operates tools. Two I-R machines supply 100-pound air for sandblasting in the paint shop, and another unit furnishes 40-pound air for general requirements and for atomizing humidifying water at the spray nozzles in the textile rooms. In addition to six machines with an aggregate capacity of 2,000 cfm., the compressor room pictured here contains five 100- to 260-ton ammonia compressors which serve to control the temperature for the various processes.

cording to the manner in which they are set. Compressed air released through the openings establishes governing pressures that activate diaphragms providing automatic variations in conformity with necessary standards. At first the plant was equipped for this purpose with many small air compressors placed at important locations, but now many miles of air lines extending from a central plant serve tanks, process rooms, driers, and baths.

At the spinning machines the piped chemical solution is again filtered, twice, before passing into the finely perforated ½-inch nozzles that direct it into a warm acid bath. The filaments, being highly alkaline, are neutralized by this contact with the acid and revert, or regenerate, to natural cellulose and assume solid form. The nozzles are known as spinnerettes and are drilled with holes from two- to five-thousandths of an inch in diameter, varying with the size and number of the filaments in the particular yarn being made. An alloy of gold and platinum is used to make these important jets so that the fine holes can be drilled with accuracy and with the proper shape. The speed of the yarn at this point may be from 60 to 100 yards per minute.

The filaments are conveyed either to bobbins or to the spinning boxes that were previously mentioned. These ingenious devices are hollow, vertical cylinders which rotate rapidly, receiving the filaments through the top by means of an inserted glass funnel. The latter rises and falls by a cam arrangement, and distributes the filaments up and down within the cylinder. Centrifugal force throws the yarn out against the walls of the cylinder, building up a "cake" which can be easily removed and reeled into skein form. When bobbins are used, the string of filaments is wound horizontally right at the spinning machine.

The yarn is then washed, desulphurized, dried, and, if necessary, bleached. Twisting machines impart strength to the yarn by wrapping the many filaments in the string into one tight piece. Winding and/or skeining follows according to the consumer's needs. Most of the yarn from this plant is shipped on cardboard cones after careful grading, sorting, and marking. The cones are packed in large wooden cases for rail or truck delivery to the knitting and weaving centers of the country.

To give an idea of the size of the plant, the twisting department alone covers an area of about 2½ acres. The winding and finishing rooms occupy approximately as much space and include air presses to compact the skeins into 10-pound packages for boxing later. An important claim by this company is that 97 per cent of all deliveries are made on time.

Bright (Briglo), medium-dull (Perlglo), and dull (Englo) lusters are furnished I. Enka, depending on the chemical and physical treatment given the yarn in the course of manufacture. A new product that has already found favorable reception is rayon yarn prepared especially for use in automobile tires. It is a fiber of probably greater tensile strength than ever before developed, and augurs well for the applications to be expected from this industry.

To serve the main departments of viscose preparation, spinning, finishing, and winding, several shops and auxiliary plants are maintained. The water demands of the plant run up to 10,000,000 gallons daily, about half of which is subjected to the usual alum and sedimentation treatment in a separate filter plant. Raw water is supplied through a 24-inch gravity line from an artificial lake fed by a mountain stream. At times, water is pumped from Hominy Creek, which serves also as a sewage-disposal outlet for the works.

The power house has an installed generating capacity of 10,000 kw. of 60-cycle electric energy, and about 3,000 kw. of special high-frequency current for specific operations. Automatic stokers receive coal from an up-to-date conveying system, and ash sluices provide for easy handling of cinders. Process steam is bled from the turbines at 18 pounds pressure and is piped through the plant with the maze of other lines. Condenser water is circulated through a spray pond. Electric current is generally distributed at 550 volts to machine motors, 3-phase circuits being commonly used. A standby arrangement is maintained with the local power company to insure a continuous supply of electricity, for the plant operates the year through with but two shutdowns for successive departments to repair or reinstall their particular machinery. These are generally scheduled for July first and the end of the calendar year.

The laboratory was mentioned previously, but other special departments or appurtenant facilities are of interest. For instance, a glass-blowing shop provides funnels for the spinning machines and other tubes and apparatus, while another manufactures and repairs the spinnerettes. The designing, construction, and up-keep of the special controls and instruments used are all done within the plant, and the usual complement of machine, carpenter, and welding shops is fully equipped for the work. The paint department is a busy one, for all spools and machinery are continually receiving special chemical lacquers so that the solutions and the easily damaged yarns will be properly fed to successive machines. To insure the best possible coating, surfaces that are to receive these lacquers are prepared by carefully sandblasting any damaged or corroded areas.

With such amply equipped plants and well-established procedures the future of the rayon industry looks promising indeed. Technical efficiency will very likely continue to improve, and the consumption curve seems to keep pace with productive capacity. A remarkable feature in this respect is that producers have been able to meet the rapid rise in demand with comparatively small increases in expenditures.

Production of rayon in the United States has tripled in the past ten years, and nearly all of it has been for home use. In reviewing the statistics of world consumption, it is observed that Germany's output was estimated at more than 500,000,000 pounds for 1939, or eight times that of 1929. This may have been due to that country's swing to rayon as a substitute for all the usual fibers, which is a significant trend and an indication of future possibilities.

MOTORING THROUGH SNOWBANKS IN MIDSUMMER

Buses of the Rocky Mountain Motor Company carrying tourists over a roadway trenched through deep drifts. Depending upon the previous winter's precipitation, scenes such as this may be viewed well into the summer.

Clearing Snow from the Nation's Backbone

Roy C. Elder

ONE of the nation's big jobs of snow removal—the clearing of the winter's accumulation from the Trail Ridge Road in Colorado's Rocky Mountain National Park—was completed in near record time this year when the rotary snowplows and bulldozers of the National Park Service cut through the 4-mile stretch that constitutes the topmost section of the highest continuous automobile road in America. That section is part of a 49-mile highway that joins the Village of Estes Park with Grand Lake and crosses the Continental Divide at an elevation of 12,183 feet. It was opened to tourist traffic on June 1, and the Rocky Mountain Motor Company began operating daily scheduled trips over it on June 20.

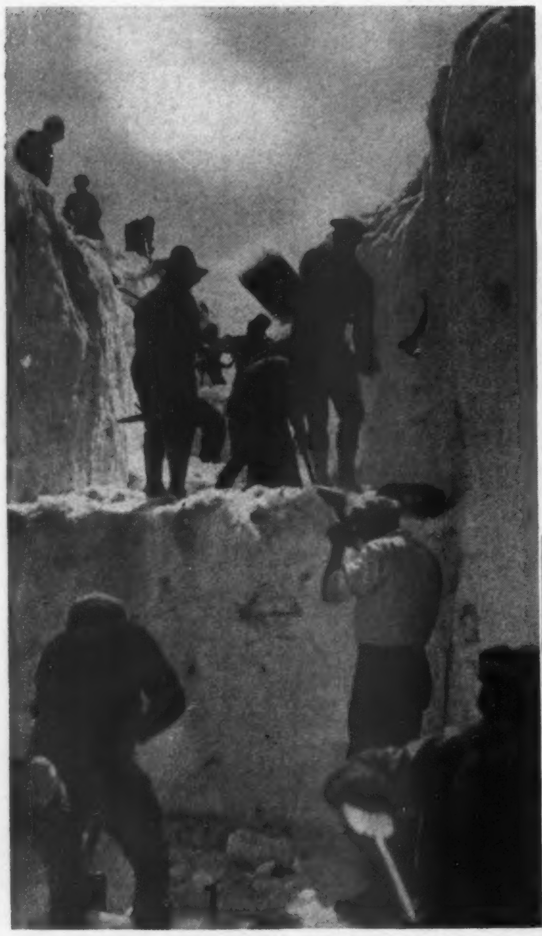
Credit for the early opening is given to the steady improvement in methods of removing tons of snow and ice. A few years ago, the road was blocked eight months or more out of the twelve: now it is closed for only six months. Picks and shovels, supplemented by innumerable boxes of dynamite, were the first tools utilized in clearing away the snow. That this procedure was both too slow and too expensive can be well imagined when it is realized that the aforementioned 4-mile section is above Elevation 12,000. At some points on this stretch the snow drifts encountered are literally mountains, 20-foot depths being nothing unusual. The expense involved also prohibited the digging of a channel wide enough for 2-lane traffic. Automobiles were forced to wait at occasional widened places until those coming from the opposite direction could pass. This necessarily slowed down the movement of cars along the entire highway.

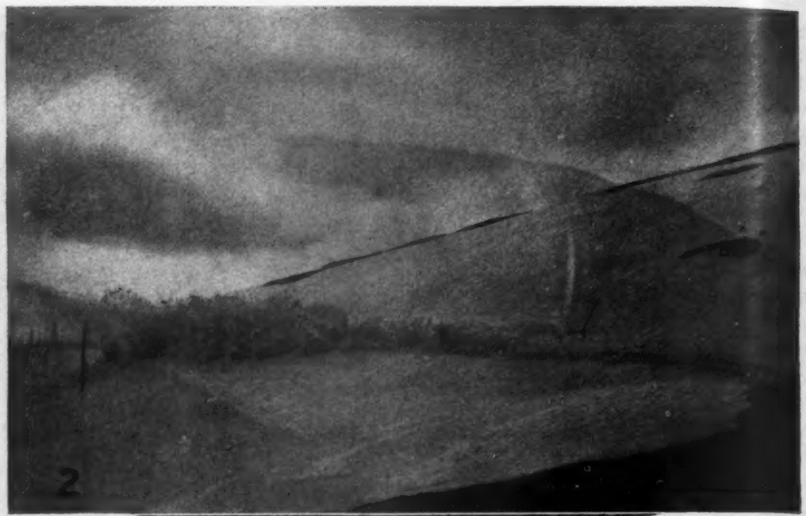
Following the pick-and-shovel period, park officials experimented with various kinds of chemicals in an effort to melt the snow. Of these, calcium carbide proved to be the most effective. But in order to melt ton upon ton of snow and ice, large quantities have to be used, and the action is slow. Consequently, this method, too, was soon scrapped. The power shovel was next tried and was at first hailed as a solution of the snow-removal problem. But, as in the case of the common hand shovel, it was found to be too slow. It could take huge bites of snow and ice; but, when it had gone a considerable distance into a high drift, the disposal of the snow presented difficulties. When working in a deep cut, the height of the banks allowed only limited side-casting, and the restricted space hampered turning of the machine for loading into trucks at the rear. Even where such loading was feasible, the snow often had to be hauled a long way to find available dumping room.

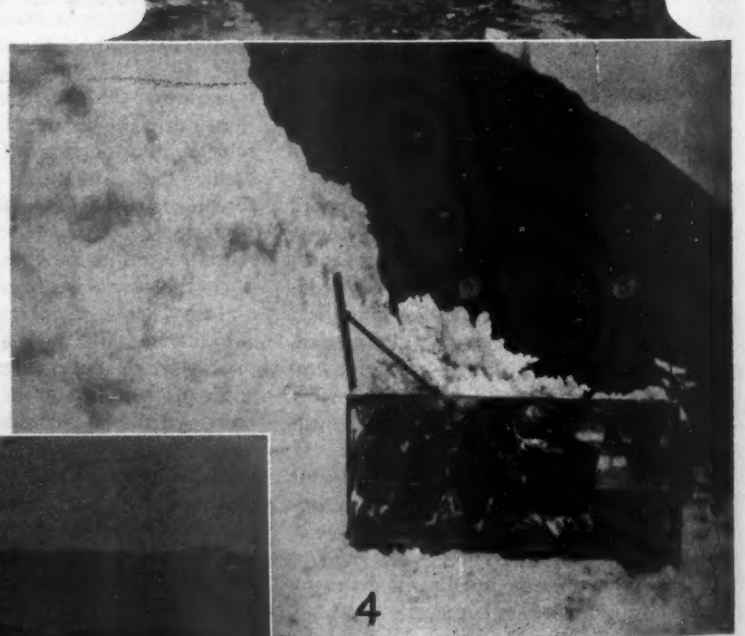
Thus the Park Service experimented each year until suitable methods and equipment were found that would clear the road quickly and economically. The modern counterparts of the power shovel and of the trucks formerly used are the auger of the rotary

TRAIL RIDGE ROAD

More than 4 miles of this 49-mile highway is above Elevation 12,000, and snowstorms are experienced every month in the year.







EVOLUTION IN SNOW-REMOVAL TECHNIQUE

1- Brigades of hand shovelers formerly dug trenches through the deep drifts, the gang on the bench rehandling the snow shoveled up to its level. It was grueling work, and the men suffered from snow blindness and sunburn. 2- One autumn, thirteen boxes of dynamite were laid along a section of roadway subject to heavy drifting and were connected with Cordeau-Bickford fuse, the end of which was run up and fastened to the top of a 20-foot pole. The following spring the charge was exploded, as shown here. The result was unsatisfactory because the concussion consolidated much of the snow into ice, which fell back into the blasted trench and presented a difficult problem of removal. 3 and 4- Power shovels and trucks were next tried but proved to be too slow and expensive. For the past several years rotary snowplows such as those shown here have expedited the operations. 5- Blade-type plows supplement the rotary machines in deep drifts and do the entire job on sections where comparatively little snow has to be removed.

snowplow, its belt, and the fan that blows out the snow. Like a modern mechanized army, heavy plows first attack the larger drifts and are followed by lighter plows that "mop up" what remains. The snow isn't pushed out of the way—rather, it is picked up by revolving blades and blown a great distance to one side or the other of the highway.

Light rotary snowplows or straight-blade steel plows are still employed to push aside snow that ranges in depth from only a few inches to 3 and 4 feet. The straight-blade plows have mold boards from 12 to 36 inches deep and are ordinarily 10 feet long and capable of cutting a swath 8 feet wide. They are mounted on the fronts of trucks and tractors by means of frames that are rigidly attached to the chassis of the equipment. The blades can be lifted hydraulically or manually and are usually constructed so that the snow can be cast to either side of the road.

The V-type plow with or without wings is particularly well suited for extremely deep snow but is little used by the Park Service. It was developed for open roads and for city streets where the snow can be cast to both sides, and is most effective for plowing an opening swath down the center. But as there is usually an obstructing wall on one side of a mountain road, the V-type plays only a small part in the removal of snow in the nation's mountainous regions.

Improvements in the design of the rotary snowplow in the past five or six years have greatly increased the efficiency of these machines. The Rotoblade, for example, is particularly well adapted for cutting through ice, its revolving blades churning the material into small and easily handled pieces. The Sno-go likewise has undergone betterment, and its augers can take bigger bites at a faster rate than formerly.

The problem of clearing snow from any mountain pass involves close study of the structure of the snow. It is necessary, for instance, to be prepared to deal with large and irregular bands of ice interspersed between layers of snow. These bands are caused by early spring thaws. Little lakes of water become "pocketed" in the snow above the roadbed, freeze at night, and are covered by subsequent snows. Park officials say that, but for these inclusions of ice, it would be a comparatively easy matter to remove snow from mountain roads. However, packed snow is almost as hard to break through, and this applies especially to snow at the bottom of a deep drift which is subjected to the pressure of that lying above it. Under such conditions the Rotoblade has to be used to cut through the compacted mass.

ROAD BLOCKED BY SNOWSLIDES

Although the deepest snowbanks are ordinarily found near the summit of the divide, where high-velocity winds pile up huge drifts, the lower reaches of the road are occasionally obstructed by heavy accumulations resulting from slides.

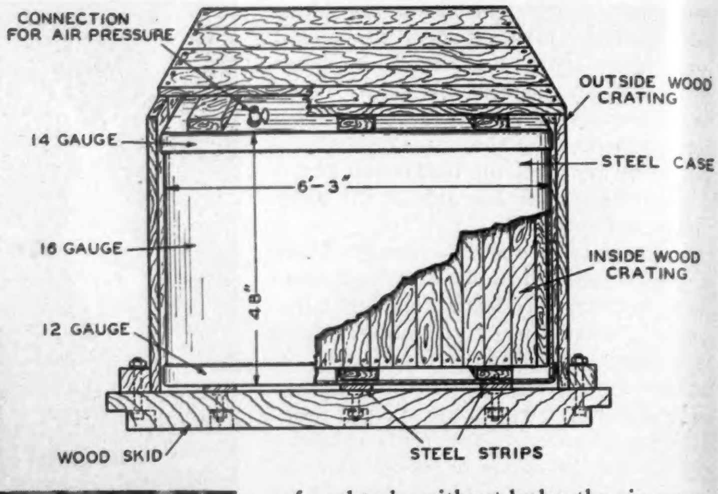
After the Rotoblade and Sno-go have disposed of the bulk of the snow and ice, the only task remaining is that of providing a clean and tractive surface for automobile traffic. This task, however, must be done thoroughly, for a sheet of ice on a high mountain pass is the worst of hazards for motor cars. Scarifiers usually serve to break up this thin layer; but even they cannot always remove all of it. When this is the case, the road must be coated with sand or cinders, and as sanding is the cheaper of the two methods, park officials use it. The only requirement with sand is that the grains shall be sharp and usually not more than ¼-inch in diameter. Two pounds to each square yard is considered sufficient to assure a tractive surface for pneumatic-tired vehicles. Drawbacks to topping with sand are that it must be removed after the ice has melted because of its abrasive action that is harmful to some pavements and because unprotected stock piles of the material are liable to freeze unless they are chemically treated. However, the addition of as little as one part of salt or calcium chloride to five parts of sand prevents freezing even of stock piles left in the open. Moreover, when such mixtures are spread on icy surfaces, the chemicals cause the ice to melt.

Officials have estimated that more than 600,000 cars will pass through Rocky Mountain National Park this year and that a fair percentage of them will go by way of the Trail Ridge Road. Buses of the Rocky Mountain Motor Company, with their headquarters at Estes Park, made two trips over the highway daily during the early part of the tourist season; but since June 20 the service has been increased to more than ten runs each day. The company has been operating on regular schedules since 1920.

HELP FROM HORSES

Here is shown a cut made by a power shovel. The first cars passing through had to be pulled by horses. By the present methods the road surface is quickly cleared for travel after the drifts are channeled.

Compressors Shipped to Tropics in Airtight Cases



ARRIVAL AT DESTINATION

Tractor and trailer upon arrival at Falls Camp on April 1 with two of the four boxes. At the right of the tractor is one of the Model 55 compressors after being unpacked and mounted on its pneumatic-tired wheels. The drawing shows details of the leakproof cases.

THREE portable air compressors were recently shipped from the United States to a remote inland point in Nicaragua in specially constructed airtight and moisture-proof packing cases. They arrived at their destination intact after several weeks in transit during which they had to be variously handled and transported. The machines were consigned to La Luz Mines, Ltd., for use on its Yy River Power Project. They were shipped by Ingersoll-Rand Company from its manufacturing plant at Painted Post, N. Y. The order, received last December, was for one Model 210A gasoline-engine-driven and two Model 55 de luxe portables, to be delivered to Siuna, Nicaragua, via Puerto Cabezas. It was specified that the maximum weight of any one box was to be 3,000 pounds, and that all cases "should be watertight as they may lay in water for weeks."

To comply with the instructions it was necessary to pack the compressors in four boxes. Each of the smaller Model 55's was shipped intact, except for removing the pneumatic wheels; but the larger 210A machine had to be partially dismantled in order to meet the maximum weight limit of 3,000 pounds. The construction of the shipping cases is shown in the accompanying sketch. Strong wooden boxes were first built. Then a 12-gauge steel pan was made to serve as a base for each box. Wooden skids were bolted underneath the pan to which the bolts were welded so as to seal those points. Next, the case was given metal sides by wrapping 16-gauge steel around it, the bottom edges being inserted between the sides of the pan and the edge of the crate. That done, all joints were welded and a metal top put on. This cap was similar to the bottom pan but of lighter material. An air connection with a globe valve was then attached to the top which was welded to the sides.

To test the tightness of the metal cases they were put under pressure by admitting a few ounces of compressed air. As all were found to be without leaks, the air was permitted to escape and the valves were closed. Finally, each was covered with a heavy wooden crate which was fastened to the wood skids. This sheathing protected the sheet metal from damage during shipment.

The three compressors were carried by rail to New Orleans, thence by boat to Puerto Cabezas, where they were delayed for some time before being taken to Prinzapolca on the river of the same name. After a further delay there, they were loaded on to two large wooden barges and towed by a small gasoline boat up the stream to Tunky. From the latter place the barges were poled about 8 miles up the Banbana River by Indian rivermen. They could proceed no farther, so a tractor was sent from the construction camp to get the cases. They were placed on a skid made of poles and dragged 3 miles upstream to the mouth of the Yy River. There they were loaded on a trailer and hauled the remaining 5 miles to Falls Camp over a recently constructed highway.

Details of the latter stages of the shipment were given in a letter received at the factory in Painted Post from Charles A. Fellencer, superintendent of the power project. He stated that none of the boxes had water in them when they were opened and that three of them were under slight air pressure. The only explanation advanced for this fact is the influence of a considerable change in temperature. On the morning of January 6 when the cases were closed at Painted Post the thermometer registered around 20°F. The consignment reached its destination in April, at which time the temperature in Nicaragua was probably somewhere between 70° and 90°, causing the air trapped in the boxes to expand sufficiently to build up noticeable pressure. Save for the tractor, which was run in overland, the compressors are the heaviest pieces of machinery ever transported into this particular section of Nicaragua.

Mr. Fellencer further wrote that the material of which the cases were constructed was being utilized in the camp. Two kitchen sinks were fashioned from some of the sheet steel, and one of the wooden boxes was used to make a coffin for a 4-month-old native boy who died a day or two after the shipment arrived.

THE AGE OF CELLULOSE

OUR times have been called the age of iron and steel, but they are as truly the age of cellulose. No other substance is so important to mankind. All hooved animals subsist principally on plant growths that are largely cellulose; and it is upon such animals that human beings depend for their meat. Cellulose gives us our textiles of cotton, linen, and rayon. Under slightly differing chemical treatments it provides us with paper, celluloid, cellophane, lacquers, and some of our explosives. We depend upon cellulose-yielding trees for our timber, so important for the construction of buildings. In the process of decaying, trees form our coal deposits; and wood may be broken down by distillation to supply us with power gas, oxalic acid, alcohol and other derivatives. Manifestly, the list of cellulose products is an almost unending one.

In this issue we take up just one of the offspring of cellulose—rayon. A newcomer among our commodities, it has gained popularity by leaps and bounds. As a substitute for silk, it has greatly upset the ancient industry of sericulture. Consider the case of Japan, which only a few years ago was economically entrenched behind a prosperous silk industry. Now the future of that industry is uncertain. Except in the case of silk stockings, for which its use has markedly increased, the United States consumes much less silk now than in the past. Japan is taking up the slack by increasing its own consumption of silk, but that seems to be largely a price-sustaining move that cannot last. Meanwhile, Japan's production of rayon has been steadily advancing. In 1929, it was only 27,000,000 pounds; in 1934 it had risen to 158,000,000 pounds; and in 1938 it was more than 584,000,000 pounds.

The ascendancy of rayon exemplifies man's ability to imitate in the laboratory a product that he cannot economically cultivate everywhere in its natural state. Numerous efforts were made to introduce silkworm culture in the United States; but they were defeated by our inability to compete with Oriental labor costs. In 1614, the good ship *Elizabeth* arrived in Virginia with a consignment of silkworms. They thrived and grew to extraordinary size on a plentiful food supply of mulberry-tree leaves; but it was soon found that serious competition with Japan was impossible.

Waiting on Nature and harvesting its crops entail certain costs that cannot be circumvented. Science, however, can break confining bonds; and so it transpired that chemists found ways to make fibers that were akin to silk. At first their quality was not of the best, and the American public formed a prejudice against rayon. Steadily, though, the product has improved, and last year we consumed more than seven times as much rayon as silk. As a consequence, the South, which gave up sericulture as a losing venture, is dotted with rayon plants that shut down only long enough to make the necessary repairs.

SOME SUBWAY HISTORY

THE idea for the first subway is said to have been advanced about 1850 by Charles Pearson, a city solicitor in London. Seven years previously a small tunnel for pedestrians had been put in service under the Thames River, and its success prompted Pearson to suggest running railroads underneath the city streets. He had a hard time selling the idea to Parliament; but in 1863 the world's initial underground railway was inaugurated. It ran between two surface railroad stations, 3½ miles apart, and saved transferring passengers much time.

America's first attempt at a subway was a circular, masonry-lined tunnel extending for 312 feet underneath Broadway from Warren Street to Murray Street in New York. It was built with great secrecy by Alfred E. Beach, an inventor; and compressed air was the motive force. Beach's company was licensed only to construct two 54-inch-diameter tubes for conveying letters, parcels, and merchandise. Beach, however, surreptitiously built a single tube 9 feet in diameter and equipped it with a passenger car accommodating 22 persons.

The tunnel was driven with the aid of a shield, which was designed by Beach. It had eighteen hydraulic jacks for shoving it ahead. The hydraulic system was operated with a hand pump, and the jacks exerted a combined pressure of 126 tons. This shield was lowered into the ground through an opening in the basement of a store run by Devlin & Company at Warren and Broadway. The shield moved ahead 16 inches with each shove, and after every advance a new ring of masonry lining was added to those already in place. The tunnel was completed in 58 working days. The shield was left where it stopped, and was dug up 39 years afterward by excavators for the B.M.T. Subway.

The Beach pneumatic-tube subway was operated for about three years, passengers being permitted to ride back and forth for about half an hour for 25 cents. The blast of air for moving the car was supplied by a large steam-driven blower at the Warren Street station. When nearing Murray Street, the conductor would ring a bell, whereupon the blower operator would reverse his machine, thus creating enough suction to stop the car. The return trip also was made by exhausting the air from the tunnel and drawing the car back. In 1873, the company obtained permission to extend the line as a passenger-carrying system; but an ensuing financial panic prevented this and even led to the abandonment of the short section already built.

New York's first full-sized subway, a part of the present network, was started in 1900 and opened for service four years later. London, Glasgow, Boston, Budapest, Paris, and Berlin already had lines in operation. At present, there are fifteen recognized subways in the world; and next year Chicago's hurrying hordes will join the ranks of the sun-dodging "straphangers."

Curtain of Water Clears Tunnel Workings After Blasting

SINCE the publication in our April issue of an article on the record-making progress of the Walsh Construction Company in advancing its section of the Delaware Aqueduct that is to supply New York City with additional water, we have received detailed information about one phase of the operations that is enabling the workers to maintain their pace with safety. Under Contract 316, the company is driving approximately 9 miles of the 45-mile Rondout-West Branch Tunnel (one of three main pressure tunnels now underway on the project) from two shafts, or four headings. These were being pushed forward at a rapid rate; but when 5,000 feet in from their respective shafts, ventilation, more particularly the menace of carbon-monoxide gas, became something of a problem.

Carbon-monoxide gas is present in the dust and smoke following a blast, and represents a hazard in tunnel driving. To clear the headings so that the men can return with safety to the working areas, it is the practice on this stretch of the aqueduct first to exhaust the air through a 26-inch duct and then to blow fresh air at the rate of 10,000 cfm. toward the faces. However, beyond 5,000 feet this ventilating system had to be supplemented if the time spent in waiting after every shot was not to become increasingly longer and slow down progress as the tunnel sections grew in length. Safety of course was the primary consideration. As the distance between the headings and the shafts became greater, it was found that the introduction of blower air only stirred up the gas, and when it was blown away from the faces so that the drillers were not endangered by it, the tunnel sections gradually became filled with carbon-monoxide-laden fumes and smoke that moved toward the shaft, menacing the drill doctor, train crew, and others that had to pass through the tunnel continually.

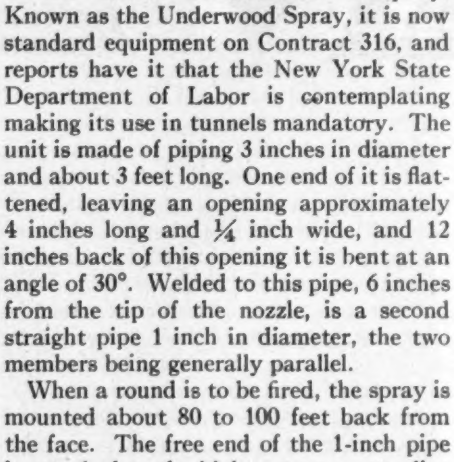
The difficulty has been overcome by means of a water-and-air spray developed after much experimenting by George Underwood, tunnel superintendent at Shaft 4, and Palmer Tubbs, safety superintendent of the Walsh Construction Company. Known as the Underwood Spray, it is now standard equipment on Contract 316, and reports have it that the New York State Department of Labor is contemplating making its use in tunnels mandatory. The unit is made of piping 3 inches in diameter and about 3 feet long. One end of it is flattened, leaving an opening approximately 4 inches long and ¼ inch wide, and 12 inches back of this opening it is bent at an angle of 30°. Welded to this pipe, 6 inches from the tip of the nozzle, is a second straight pipe 1 inch in diameter, the two members being generally parallel.

When a round is to be fired, the spray is mounted about 80 to 100 feet back from the face. The free end of the 1-inch pipe is attached to the high-pressure water line that feeds the drills on the drill carriage, and the 3-inch line is connected by a swivel joint to the main high-pressure air line. When the blaster has connected his lead lines, he turns on the water and then the air before retiring to close the safety switch. The water is delivered at a pressure of 75 pounds per square inch and the compressed air at 100 pounds; and because of the angle of the discharge end of the unit, which offers sufficient leeway to adjust the stream, it is possible to throw a heavy curtain of water, or approximately 125 gallons a minute, the entire width of the tunnel. It usually sprays for from five to ten minutes before the round is fired, and continues to run as the blast gases, smoke, and dust are blown toward and into the falling water. Anything passing through the curtain is forced back through it as soon as the blower at the head of the shaft begins to exhaust the air, thus virtually clearing the atmosphere of every trace of gas, smoke, and dust.

When the blaster and his helper return to inspect the heading, the water and the air are turned off and the spray is hung on the tunnel wall ready for the next shot. According to *The Delaware Water Supply News*, organ of the New York Board of Water Supply, tests show that five minutes after a blast there is practically no carbon monoxide, combustible gas, powder smoke, or fumes left. The muck pile, the heading, and the walls have been wet down by the action of the spray, and the men can return to the heading within five to fifteen minutes after firing. The air is clean, and the smoke cone and dust that usually hang at the heading and are blown back toward the shaft after the fans are reversed are practically eliminated. This spray saves more time (5 to 20 minutes per shot) and gets rid of the gas, smoke, and dust nuisance faster than anything that has been tried. Since its introduction, progress at the four headings has increased with distance instead of fallen off, proving that safe and healthy working conditions can be maintained in tunnels without sacrificing speed of advance.

Gasket Renewal for Flanged Pipe Simplified

FOR replacing gaskets in flanged pipe lines, The Garlock Packing Company is introducing what are known as Flange-Jacks which, it is claimed, make this normally hard work an easy one. They are used in pairs. For their application it is necessary to remove from the flanges two bolts at points 180° from each other. Into each of these two openings are inserted the jaws of a jack, the screws of both then being tightened sufficiently to hold them in place. After the remaining bolts have been withdrawn, the screws are tightened simultaneously, causing the jacks to separate the flanges gradually and evenly. When the space is wide enough, it is a simple matter to take out the old gasket, clean the flange faces, and put in a new one. That done, the operations are reversed: the jackscrews are backed off, the jacks removed, and the bolts applied.



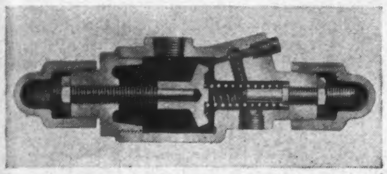
The work is done without the use of hammers, chisels, and wedges, without strain or vibration, and for that reason the gasket is in proper position and the pipe in alignment. Laboratory tests have proved that the tools can open joints against a load of 15 tons without difficulty and without damaging either the jacks or the flanges. The jaws are heavy, 1-piece steel forgings and the steel screws have case-hardened points. Flange-Jacks come in three sizes: Midget, for pipes less than 2 inches; Standard, for 2- to 20-inch flanges; and Giant, for 14- to 48-inch flanges. They weigh from 3 to 50 pounds ready for shipping.

Paper-Encased Drill Hole

IN THE Chuquicamata Mine of the Chile Copper Company it is the practice in the open workings, which lie at an altitude of 9,200 to 10,000 feet, to drill 8-inch holes to a depth of 42.5 feet on approximately 13-foot centers 23 feet back from the toe of each of the numerous benches now undergoing development. To prevent these holes from caving in, they are protected at the top by casing up to 8 feet long. Just how many holes are involved can be appreciated when it is known that sixteen benches, with faces aggregating 52,000 feet, were ready for blasting in January of this year and that anywhere from 60 to 250 holes are shot at a time. This probably explains why the company has discarded heavy iron casing and is using instead "casing prepared of paper," to quote a recent issue of the *Foreign Minerals Quarterly* published by the U. S. Bureau of Mines.

Industrial Notes

D. J. Murray Manufacturing Company is offering an improved type of safety valve for flexible hose used to carry fluids or gases under pressure. It is designed, in case of accidental uncoupling or breakage of a line, to shut off the flow of air, steam, water, etc., promptly and automatically, and in the same way to supply it again as soon as repairs have been made. The Murray-Lorge, as it is called, permits an operator to change tools without turning the power



off and on, as the action of disconnecting and connecting them does this for him. Under normal working conditions, the pressure at the inlet and outlet of the valve is nearly the same and a plunger is held in the open position by a spring, allowing the gas or fluid to flow around it. But when the hose beyond the valve outlet is damaged through any cause, and the pressure balance is destroyed, the plunger slides tight against the valve seat, shutting off the supply. Conversely, as soon as the pressure is again equalized, the service is restored. The valve is available in a number of sizes.

An adhesive-impregnated material that is designed to make flat-belt pulleys proof against slippage has recently been placed on the market. It comes in sheets, 9 feet square, which are torn into strips of the desired width and length. Before application they are soaked in hot water and the pulleys are freed of all grease and oil. The company is prepared to furnish samples.

Howe Machinery Company has announced an improvement in its V-belt measuring machine by means of which V belts for multiple drive can be matched correctly as to length just before application. The belts are placed, one at a time, over a pair of suitable sheaves and then subjected to any predetermined tension up to 400 pounds. This is registered on a dial, and the length is indicated on a tape between the sheave-carrying heads. The apparatus is designed for A to E belts up to 420 inches long.

Milburn Company is offering an industrial vanishing cream for the use of welders and cutters. It is rubbed into the skin until dry and is said to protect it from burns that are apt to be severe especially when working with large-diameter rods. The ingredients counteract the injurious ultraviolet and infrared rays, against which even several layers of clothing are no safeguard. With a coating of Ply No. 8 a welder can, it is claimed, work scantily clad for comfort with safety. It is also a sunburn preventive. The preparation is sold in 6-ounce glass jars.

Something new in reinforced-concrete building materials is reported from Sweden. Tough steel wire, 2 mm. in diameter, is used in place of the familiar bars, and is fastened in the forms stretched taut. As soon as the concrete has set sufficiently, the hold or tension on the wire is released. The result is what is called a highly elastic concrete section. So strengthened, a beam of a given size, for example, is said to require only one-twentieth as much reinforcing as it normally would, and fewer of them are needed to support a given load.

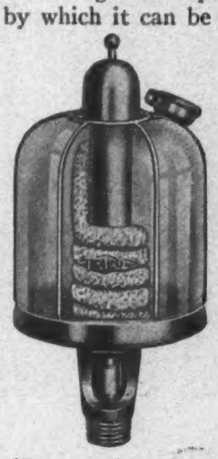
Recent discoveries of iron ore at Steep Rock Lake, Canada, have brought the total known reserves of high-grade hematite in the region up to at least 200,000,000 tons, it is reported. The question is whether it would be more profitable to recover it by underground mining or to divert Seine River and drain the lake so as to get out all the ore. This would involve an expenditure estimated at $4,000,000, but would, it is believed, be more than offset by the large quantities of ore in the 300-foot-thick ceiling that would have to be left if the property were developed by underground methods.

Plastic tubing for the protection of electric wiring in plants where it would be exposed to oil, coal-tar solvents, denatured alcohol, petroleum products, acids, and alkalies in concentrations up to 30 per cent by weight is being made in continuous lengths by the extrusion process by the Irvington Varnish & Insulator Company. The wire is threaded through the tubing. So encased, it is said that it can be bent upon itself and returned to its original form without cracking, that it will remain flexible at temperatures down to −4°F., and that it will retain its shape at temperatures up to 300°F. It is sold under the name of Irv-o-lite Type XTE-30 and is available in five standard colors and in sizes from No. 20 to 5/8 inch.

From Sweden comes the announcement that the Boliden Mining Company has produced a highly satisfactory arsenic timber-impregnating compound that is deadly to insect pests but harmless to higher forms of animal life and human beings. It is claimed that the solution sets up chemical reactions in the wood itself, resulting in the formation of zinc and chromic arsenate. These become inseparable constituents of the woody structure and make it proof against rot and attack by insects, including termites. Timber so treated is slightly green in color tinged with brown and does not require painting for use in buildings. So far the experiments have concerned mostly pine. What method of impregnation is employed is not divulged; but it is said that twelve plants have already been built in different parts of Sweden to supply the increasing demand for the material for outdoor and underwater construction purposes.

On the Pacific Coast there is being built a new type of railroad passenger car. It is known as the Hill Car, and features a free-floating body supported at its four corners by tall coil springs. These act as shock absorbers and virtually eliminate vibration. The construction, according to F. G. Gurley, vice-president of the Santa Fe, permits the bottom of the car to move outward on curves and the gondolalike upper structure inward, thus making it possible to negotiate them safely and without discomfort to the occupants at a higher speed than is permissible with existing equipment. Three such cars are now being built.

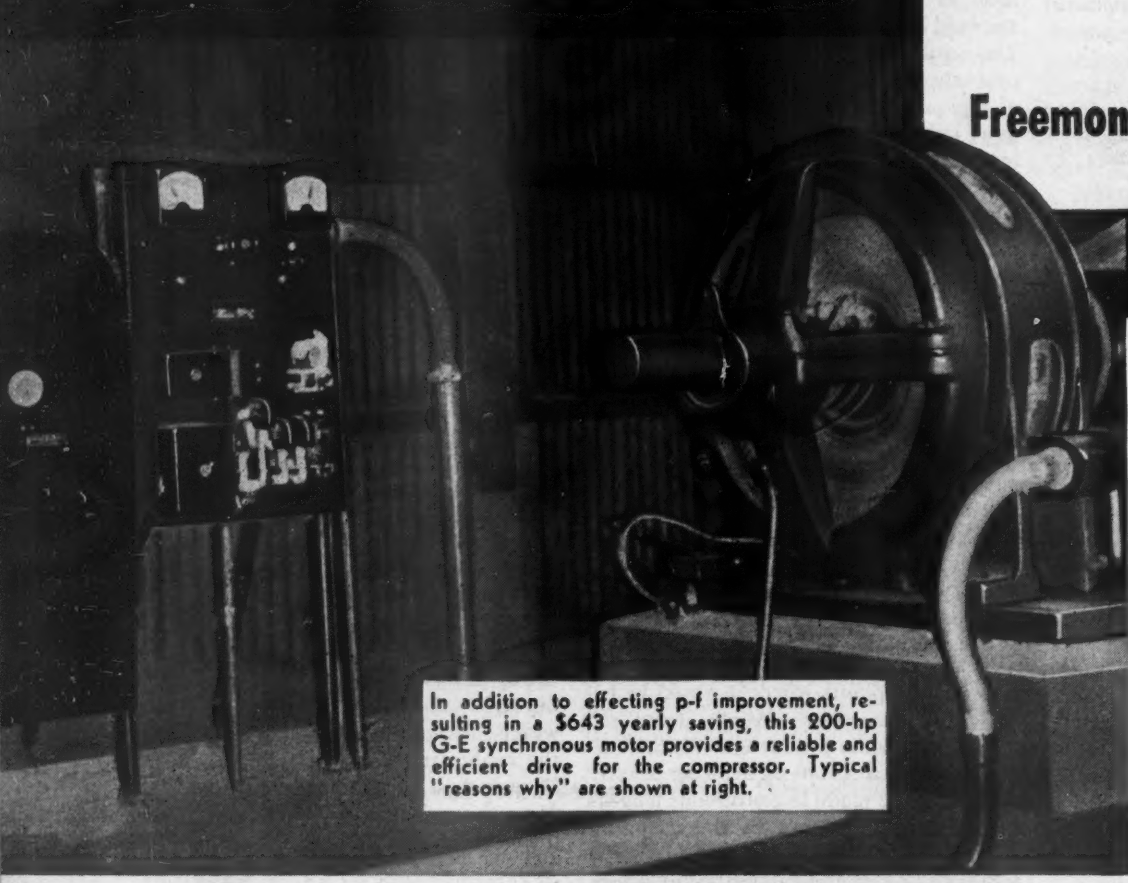
The wick-feed oiler shown here has been designed by the Trico Fuse Manufacturing Company for machinery that operates intermittently. The reservoir is unbreakable and clear and has a self-closing filler cap with an extended lip by which it can be raised by the spout of the oil can. The wick is wire-reinforced for rigidity. Feed is controlled by a small lever at the top, and when the container is filled beyond the level where the wick enters the center tube, the surplus oil drains down through it into the bearing, flushing it thoroughly. Thereafter the wick feeds the lubricant automatically through capillary action, preventing flooding and waste when the machine is idle. The new oiler is available in 1-, 2-, and 4-ounce sizes.



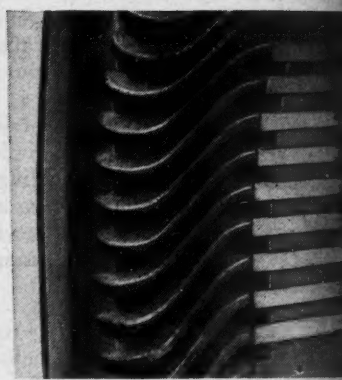
With its new tension meter, The Hazard Wire Rope Division of The American Chain & Cable Company claims that anyone can measure the actual load on a wire rope or solid wire. The instrument weighs less than a pound and operates on a simple, basic principle—the definite relationship between the tension and tone pitch of a loaded wire. It has a standard tuning wire and calibrated scale and measures the tension by comparing the tone given off by the loaded wire when plucked with that of the standard wire. The actual load in pounds, together with safety factors for any type of wire of any size up to 3/8 inch in diameter, is given in a set of tables to which the figures on the calibrated scale refer. An Acco Tension Meter for larger sizes is being developed.

CALIFORNIA GOLD MINE CUTS POWER COST

ONE G-E synchronous motor saves $643 a year for the Freemont-Gover Company



In addition to effecting p-f improvement, resulting in a $643 yearly saving, this 200-hp G-E synchronous motor provides a reliable and efficient drive for the compressor. Typical "reasons why" are shown at right.



Exceptionally long life is made possible by the great mechanical strength of the stator-coil insulation, and because of the use throughout of non-aging insulating varnishes and compounds.

By installing one G-E synchronous motor to drive an air-compressor, this gold-mining company improved its power-factor and made a saving of more than $50 a month in power cost.

Synchronous motors are the most efficient and reliable drives known for compressors, pumps, and other constant-speed applications. There are on record hundreds of examples of substantial savings and improved operation of electric equipment made possible by their use.

G-E synchronous motors operate at unity or leading power-factor, depending on design, and though requirements of users may vary, exactly the right motor needed can be supplied for each job. For further information, ask your nearest G-E representative, or write General Electric, Schenectady, N. Y.

SEE THE G-E "HOUSE OF MAGIC" AT BOTH FAIRS

Field coils consist of rectangular, pretreated, insulated copper wire, thoroughly impregnated with a hard, protective insulation.

Ample protection of the stator end windings is provided by strong die-formed steel shields which do not restrict ventilation. They are bolted securely to the stator frame, and to each other.

GENERAL ELECTRIC

000-2